Facility name: South Cavalcade

Location: Between Cavalcade and Collingsworth Streets, Houston, Texas

EPA Region: VI, Dallas, Texas

Person(s) in charge of the facility: Various, See Attachment 1

Name of Reviewer: Charles Faulds Date: April 16, 1984

General description of the facility:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility; contamination route of major concern; types of information needed for rating; agency action, etc.)

Abandoned creosote wood-treating waste disposal site. Contaminants at the site consist of polynuclear aromatic compounds associated with creosote in addition to some pentachlorophenol. Historical air photographs indicate at least three waste pits. Present data indicates widespread surface contamination in addition to soil and ground water contamination.

Scores: S_M = 38.69 (S_{gw} = 66.94 S_{sw} = 0.00 S_a = 0)

S_{FE} =

S_{DC} =

FIGURE 1
HRS COVER SHEET

1012172

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South Cavalcade Site Summary

The South Cavalcade site has had a history of wood-treating operations dating to 1911. Contaminants at the site consist of polynuclear aromatic compounds associated with creosote, in addition to other similar contaminants. The site covers approximately 46 acres and is located about one mile southwest of the intersection of Interstate loop 610 and U. S. Route 59 in Houston, Harris County, Texas. The site is bounded on the south by Collingsworth Street with Houston Belt and Terminal rail lines forming approximate boundaries on two sides, and Cavalcade Street on the north. Historical air photographs indicate at least three waste pits in the site, which have been subsequently filled or paved over. Present data indicates widespread surface contamination in addition to soil and shallow ground water contamination.

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Ground Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score	Ref. (Section)
1 Observed Release	0 45	1	0	45	3.1
If observed release is given a score of 45, proceed to line 4. If observed release is given a score of 0, proceed to line 2.					
2 Route Characteristics					3.2
Depth to Aquifer of Concern	0 1 2 3	2	6	6	
Net Precipitation	0 1 2 3	1	1	3	
Permeability of the Unsaturated Zone	0 1 2 3	1	3	3	
Physical State	0 1 2 3	1	3	3	
	Total Route Characteristics Score		13	15	
3 Containment	0 1 2 3	1	3	3	3.3
4 Waste Characteristics					3.4
Toxicity/Persistence	0 3 6 9 12 15 18	1	18	18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1	6	8	
	Total Waste Characteristics Score		24	26	
5 Targets					3.5
Ground Water Use	0 1 2 3	3	6	9	
Distance to Nearest Well/Population Served	0 4 6 8 10 12 16 18 20 24 30 32 35 40	1	35	40	
	Total Targets Score		41	49	
6 If line 1 is 45, multiply 1 x 4 x 5 45 x 24 x 41 If line 1 is 0, multiply 2 x 3 x 4 x 5			38376	57,330	
7 Divide line 6 by 57,330 and multiply by 100		S_{gw} = 66.94			

FIGURE 2
GROUND WATER ROUTE WORK SHEET

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Surface Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score	Ref. (Section)
1 Observed Release	0 45	1	0	45	4.1
If observed release is given a value of 45, proceed to line 4. If observed release is given a value of 0, proceed to line 2.					
2 Route Characteristics					4.2
Facility Slope and Intervening Terrain	0 1 2 3	1	1	3	
1-yr. 24-hr. Rainfall	0 1 2 3	1	3	3	
Distance to Nearest Surface Water	0 1 2 3	2	4	6	
Physical State	0 1 2 3	1	3	3	
	Total Route Characteristics Score		11	15	
3 Containment	0 1 2 3	1	3	3	4.3
4 Waste Characteristics					4.4
Toxicity/Persistence	0 3 6 9 12 15 18	1	18	18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1	6	8	
	Total Waste Characteristics Score		24	26	
5 Targets					4.5
Surface Water Use	0 1 2 3	3	0	9	
Distance to a Sensitive Environment	0 1 2 3	2	0	6	
Population Served/Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	1	0	40	
	Total Targets Score		0	55	
6 If line 1 is 45, multiply 1 x 4 x 5 45 x 24 x 3 If line 1 is 0, multiply 2 x 3 x 4 x 5			0	64,350	
7 Divide line 6 by 64,350 and multiply by 100		S_{sw} =	0		

FIGURE 7
SURFACE WATER ROUTE WORK SHEET

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Air Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max Score	Ref. (Section)
[1] Observed Release	0 45	1		45	5.1
Date and Location:					
Sampling Protocol:					
If line [1] is 0, the S_a = 0. Enter on line [5]. If line [1] is 45, then proceed to line [2].					
[2] Waste Characteristics					5.2
Reactivity and Incompatibility	0 1 2 3	1		3	
Toxicity	0 1 2 3	3		9	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				20	
[3] Targets					5.3
Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	1		30	
Distance to Sensitive Environment	0 1 2 3	2		6	
Land Use	0 1 2 3	1		3	
Total Targets Score				39	
[4] Multiply [1] x [2] x [3]				35,100	
[5] Divide line [4] by 35,100 and multiply by 100	S_a =				

FIGURE 9
AIR ROUTE WORK SHEET

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	S	S^2
Groundwater Route Score (S_{gw})	66.94	4480.80
Surface Water Route Score (S_{sw})	0	0
Air Route Score (S_a)	0	0
$S_{gw}^2 + S_{sw}^2 + S_a^2$		4480.80
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$		66.94
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} \,/\, 1.73 = S_M =$		38.69

FIGURE 10
WORKSHEET FOR COMPUTING S_M

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Fire and Explosion Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multiplier	Score	Max. Score	Ref. (Section)
[1] Containment	1 3	1		3	7.1
[2] Waste Characteristics					7.2
Direct Evidence	0 3				
Ignitability	0 1 2 3	1		3	
Reactivity	0 1 2 3	1		3	
Incompatibility	0 1 2 3	1		3	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		3	
				8	
Total Waste Characteristics Score				20	
[3] Targets					7.3
Distance to Nearest Population	0 1 2 3 4 5	1		5	
Distance to Nearest Building	0 1 2 3	1		3	
Distance to Sensitive Environment	0 1 2 3	1		3	
Land Use	0 1 2 3	1		3	
Population Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Buildings Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Total Targets Score				24	
[4] Multiply [1] x [2] x [3]				1,440	
[5] Divide line [4] by 1,440 and multiply by 100	S_{FE} =				

FIGURE 11
FIRE AND EXPLOSION WORK SHEET

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Direct Contact Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Incident	0 45	1		45	8.1
If line 1 is 45, proceed to line 4 If line 1 is 0, proceed to line 2					
2 Accessibility	0 1 2 3	1		3	8.2
3 Containment	0 15	1		15	8.3
4 Waste Characteristics Toxicity	0 1 2 3	5		15	8.4
5 Targets					8.5
Population Within a 1-Mile Radius	0 1 2 3 4 5	4		20	
Distance to a Critical Habitat	0 1 2 3	4		12	
Total Targets Score				32	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				21,600	
7 Divide line 6 by 21,600 and multiply by 100		S_{DC} =			

FIGURE 12
DIRECT CONTACT WORK SHEET

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DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUCTIONS: The purpose of these records is to provide a convenient way to prepare an auditable record of the data and documentation used to apply the Hazard Ranking System to a given facility. As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludges"). The source of information should be provided for each entry and should be a bibliographic-type reference that will make the document used for a given data point easier to find. Include the location of the document and consider appending a copy of the relevant page(s) for ease in review.

FACILITY NAME: South Cavalcade

LOCATION: Between Cavalcade and Collingsworth Streets, Houston, Texas

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GROUND WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected (5 maximum):

Rationale for attributing the contaminants to the facility:

000395

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifers(s) of concern:

Guld Coast aquifer
TDWR Report #238, see attachment #5)

Depth(s) from the ground surface to the highest seasonal level of the saturated zone [water table(s)] of the aquifer of concern:

10', see attachment 5

Depth from the ground surface to the lowest point of waste disposal/ storage:

2', see attachment #4

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Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Sum of mean monthly precipitation for Nov.- Apr. = 20.5"
Climatic Atlas of Texas Dec. 1983

Mean annual lake or seasonal evaporation (list months for seasonal):

Sum of mean monthly evaporation for Nov. - Apr. = 18"

Net precipitation (subtract the above figures):

2.5"

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Sands, clay, gravel (TDWR Report #238, page 39; attachment #5.

Permeability associated with soil type:

$>10^{-3}$ cm/sec
(NCP guidance)

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

Sludges - Site assessment report (last attachment)

* * *

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000396

3 CONTAINMENT N/A

Containment

Method(s) of waste or leachate containment evaluated:

Impoundment, unsound division system (see site inspection report)

Method with highest score:

Impoundment

HRS = 3

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:

Chrysene
Benzo(a)pyrene
Fluoranthene
Anthracene

(Attachment 2, p. 6-8, 6-10, 6-13)

Compound with highest score:

Benzopyrene: Toxicity = 3 (Sax, p. 407)
Persistence = 3 (NCP) Table 5

Chrysene: Toxicity = 3 (Sax, p. 506)
Persistence = 3 (poly cyclic compound)

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

637 yd^3

Basis of estimating and/or computing waste quantity:

See Attachment 4

* * *

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000397

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5 TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

Municipal, industrial, domestic water supply

Other wells in the city system, outside the three mile radius, could supply the area, if necessary.

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

From Harris-Galveston Coastal Subsidence District Records Well No. 2334.

(See Attachment 5)

Distance to above well or building:

Approximately ½ mile east of site.

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and populations served by each:

TDWR Report 238, page 39, states that the Gulf Coast Aquifer consists of alternating beds of clay, silt, sand, and gravel which are hydrologically connected and form a large, leaky artesian aquifer system, thus all wells within three miles are of concern. (See Attachment 5)

Computation of land area irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

N/A

Total population served by ground water within a 3-mile radius:

U.S. Census Bureau data 1,600,000 people in city of Houston (1980)

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000398

SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

Rationale for attributing the contaminants to the facility:
These organics are associated with waste products of the creosote wood-treating process.

* * *

2 ROUTE CHARACTERISTICS N/A

Facility Slope and Intervening Terrain

Average slope of facility in percent:

3% USGS Topographic map of Houston

Name/description of nearest downslope surface water:

Hunting Bayou (USGS Topographic map and
CDM Report attached)

Average slope of terrain between facility and above-cited surface water body in percent:

3% USGS Topgraphic map of Houston

Is the facility located either totally or partially in surface water?

No

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00039 9

Is the facility completely surrounded by areas of higher elevation?

No, USGS map of Houston

1-Year 24-Hour Rainfall in Inches

3.8 inches (NCP Guidance)

Distance to Nearest Downslope Surface Water

0.5 miles (attachment 2, page 7-3)

Physical State of Waste

Sludges (see groundwater route)

* * *

3 CONTAINMENT N/A

Containment

Method(s) of waste or leachate containment evaluated:

Waste piles (contaminated soil, CDM Report)

Method with highest score:

Waste piles, HRS = 3

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000400

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

Same as ground water (See page 4)

Compound with highest score:

See p. 4

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

See p. 4

Basis of estimating and/or computing waste quantity:

See p. 4

* * *

5 TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

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Is there tidal influence?

Slight, in Houston Ship Channel

Distance to a Sensitive Environment N/A

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Population Served by Surface Water N/A

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

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Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

Total population served:

Name/description of nearest of above water bodies:

Distance to above-cited intakes, measured in stream miles.

000403

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AIR ROUTE

1 OBSERVED RELEASE

Contaminants detected:

Date and location of detection of contaminants

Methods used to detect the contaminants:

Rationale for attributing the contaminants to the site:

* * *

2 WASTE CHARACTERISTICS

Reactivity and Incompatibility

Most reactive compound:

Most incompatible pair of compounds:

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000404

Toxicity

Most toxic compound:

Hazardous Waste Quantity

Total quantity of hazardous waste:

Basis of estimating and/or computing waste quantity:

000405

* * *

3 TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi   0 to 1 mi   0 to 1/2 mi   0 to 1/4 mi

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

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Distance to critical habitat of an endangered species, if 1 mile or less:

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

000406

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

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Attachment One

South Cavalcade Person(s) in Charge of the Facility

Subdividing of the land in the area has increased the number of landowners at the site. Several commercial/industrial operations are ongoing. A partial list includes:

A. Merchants Trucking
   Contact: Jim Harbison, Attorney
   P. O. Box 391
   Houston, Texas 77001
   713/739-0010

B. Rex King
   Pallatized Trucking
   713/225-3303

C. Baptist Foundation of Texas
   leased to Transcon Trucking Lines
   Calvin Reeves
   214/922-0125

D. Houston Belt & Terminal Railway Co.
   John Pruetz
   713/546-3102

000407

ATTACHMENT 2

Summary of Analytical Results

Excerpt from
Cavalcade Contaminant Survey
Volume I
Engineering Report
by
Camp Dresser & McKee, Inc.
In Association with
McClelland Engineers, Inc.
July 11, 1983

000408

6.3 Sediment Sampling (SD)

Objectives. Representative bottom sediments samples were collected along the course of the drainage ditch at the southeast corner of the site. These samples were collected to establish a bottom sediment quality baseline prior to any remedial action or construction activity. [illegible] were collected offsite along the railroad drainage ditch on the southeast corner of the site to determine if any offsite migration of contamination was occurring.

Sampling Procedures. Six (6) bottom sediment samples were collected from the drainage area on the southern end of the site. A grab sampling technique as referenced in Procedure No. 3816012 of the CDM Generic Sampling and Analytical Plan for Uncontrolled Hazardous Waste Sites was used. For collection, the single tube core shallow water sidement (WILDCO 2400-A15) was used at all sampling locations. All sampling locations are identified on Figure 6-1. These sampling locations were co-located to surface water sample collection locations. All quality assurance, personal protection, special hazard precautions and chain-of-custody/documentation procedures identified in the Site Specific Health and Safety/Sampling and Analytical Plan for the Cavalcade Yard Site were adhered to.

Sample Identification. For each individual sample collected, the sample numbering procedure identified in Appendix I was followed. A summary of all samples and locations are presented on Table 6.3. Sampling log sheets are also presented for each sample location in Appendix II.

Summary of Analytical Results

During the sediment sampling program, the following toxic compounds were encountered at concentrations above detection limits as specified by the analytical techniques utilized.

Volatile Organics (all values PPB, ug/kg wet weight)

Contaminant	SD-01	SD-02	SD-03	SD-04	SD-05
Methylene Chloride	100	48	83	110	39

Refractory Organics (all values PPB, ug/kg, wet weight)

Contaminant	SD-01	SD-02	SD-03	SD-04	SD-05
Anthracene	240.	4700.	1600.	2100.	ND
Benzo(a)anthracene	550.	440.	620.	18000.	ND
Benzo(a)pyrene	500.	250.	600.	5400.	ND
3,4-Benzofluoranthene	1100.	890.	1300.	4800.	ND
Benzo(g,h,i)perylene	430.	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	210.	ND	ND	ND	ND
Chrysene	550.	530.	680.	14000.	ND
Floranthene	1100.	750.	1200.	25000.	320.
Indeno(1,2,3,-c,d)pyrene	320.	ND	600.	ND	ND
Phenanthrene	650.	ND	860.	14000.	ND
Pyrene	850.	690.	1100.	·22000.	260.
Fluorene	ND	360.	ND	520.	ND
Aceraphthene	ND	ND	ND	580.	ND

Toxic Metals and Inorganics (all values PPM, mg/Kg, wet weight)

Contaminant	SD-01	SD-02	SD-03	SD-04	SD-05
Arsenic (As)	2.0	2.4	1.5	2.2	1.5
Beryllium (Be)	0.2	0.6	0.3	0.5	0.2
Cadmium (Cd)	0.8	0.6	1.0	1.4	ND
Chromium (Cr)	10.0	13.0	12.0	9.7	6.8
Copper (Cu)	13.0	60.0	21.0	82.0	21.0
Lead (Pb)	61.0	88.0	69.0	185.0	20.0
Mercury (Hg)	0.025	0.043	0.032	0.006	0.006
Nickel (Ni)	4.5	4.9	5.4	2.7	2.7
Silver (Ag)	0.40	0.06	ND	ND	ND
Thallium (Th)	ND	0.06	0.97	ND	ND
Zinc (Zn)	160.0	150.0	150.0	30.0	30.0

Discussion of Analytical Results. Volatile organic contamination of sediments both on and off site are of minimum environmental significance. The one volatile organic compound encountered, methylene chloride is a notorious laboratory contaminant. As a result, the low level (less than 1 PPM) methylene chloride sediment contamination indicated should be evaluated accordingly.

000410

The prevalence of low level refractory organic compound, particularly the polynuclear aromatic hydrocarbon constituents is consistent with the disposal practices of the low technology creosoting operations previously identified as operating at this site. The creosote waste products disposed of at this site over two decades ago have been subjected to the natural "weathering" forces of the environment (evaporation, biological decomposition, etc.) and as a result, only the more refractory nonvolatile, and/or persistent compounds remain in the sediment. **It should be noted that the highest concentration of these compounds are encountered off-site (SD-04) in the railroad drainage ditch to the east of the site.**

The toxic metal contamination associated with on-site sediments SD-01, SD-02, SD-03, although posing no significant environmental impact may prove problematical with respect to ultimate disposal. The ability of this material to meet the requirements of the EP toxicity test (SW-846 Methods 3510 and 8080) with lead assays in excess of 50 PPM (wet weight basis) is questionable.

000411

000411

6.4 Surface Water Sampling

Objectives. Representative surface water samples were collected; (1) along the south site drainage ditch, and (2) along the course of the railroad bed drainage ditch. These samples were collected to establish surface water quality in the vicinity of the Cavalcade Yard Site and determine the relationship between surface waters and the various waste disposal areas situated in close proximity to the tributaries course.

Sampling Procedures. Two (2) surface water samples were collected from the drainage areas. A grab type sampling method (reference No. 816002) as identified in the CDM Generic Sampling and Analytical Plan for Uncontrolled Hazardous Waste Sites was used. All sampling locations are identified on Figure 6-1. These sampling locations were co-located to sediment sample locations. All quality assurance, personal protection, special hazard precautions and chain-of-custody/documentation procedures identified in the Site specific Health and Safety/Sampling and Analytical Plan for the Cavalcade Yard Site were adhered to.

Sample Identification. For each individual sample collected, the sample numbering procedure identified in Appendix I was followed. A summary of all samples and locations are presnted on Table 6.4. Sampling log sheets are also presented for each sample location in Appendix I.

Summary of Analytical Results. During the surfacewater (SW) sampling program, the following toxic compounds were encountered at concentrations above detection limits as specified by analytical techniques utilized.

Volatile Organics

No volatile organics detected.

Refractory Organics (all values reported as PPB, ug/l)

Contaminant	SW-01	SW-02
Benzo(a)anthracene	ND	10.
Benzo(a)pyrene	ND	10.
3,4-benzofluoranthene	ND	21.
Benzo(k)fluoranthene	ND	21.
Chrysene	ND	12.
Di-n-butyl phthalate	ND	18.
Fluoranthene	ND	17.
Pyrene	ND	14.

000412

Toxic Metals and Inorganics (all values removed as PPM, mg/l)

Contaminant	SW-01	SW-02
Cadmium (Cd)	0.05	ND
Zinc (Zn)	0.32	0.18

Discussion of Analytical Results. There is no indication of surface water contamination on site as indicated by the absence of volatile organics, refractory organics and toxic metals in excess of primary (0.05 PPM Cd) and secondary (5.0 PPM Zn) drinking water standards at location SW-01.

Low-level contamination (<100 PPB) of a variety of polynuclear aromatic hydrocarbon was observed in the railroad drainage ditch to the east of the site.

000413

6.5 Surface Soil Sampling (SL)

Objectives. Six (6) surficial soil samples were collected to characterize the physical nature of the soils present on the site and determine the degree of contamination of the soils located adjacent to areas used or alleged to be used for waste disposal. No off-site samples were collected to quantify the degree of contamination at the site to the immediate surrounding environment. These samples were collected at locations suspected of containing large deposits of creosote and wood-preserving products.

Sampling Procedures. A total of six (6) surficial soil samples were collected a various locations at the site. A review of initial surveys and aerial photographs has revealed areas of potential contamination that were investigated by probing shallow depths. Hand operated soil augers were used to obtain these surficial soil samples. The procedures for general soil sampling (reference No. 3816099) and surface and shallow depth soil sampling (reference No. 3816029) from the CDM Generic Health and Safety Plan were followed during sampling activities. All quality asurance, personal protection and chain-of-custody/documentation procedures included in the Site Specific Health and Safety/Sampling and Analytical Plan for the Cavalcade Yard Site (Appendix II) were followed during this sampling activity. These samples were used in conjunction with the deep soil borings to provide a complete description of the chemical characteristics of the soil and contamination at this site.

Sample Identification. Each surficial soil sample collected was recorded by the method identified in the site specific plan contained in Appendix I. A summary of all samples and locations are presented on Table 6.5 Sampling location log sheets are also presented for each sample location in Appendix II.

Summary of Analytical Results. During the Surface Soil (SL) Sampling Program, the following priority pollutant compounds were encountered on site at concentrations above detection limits as specified by analytical techniques specified.

Volatile Organics (all values PPB, ug/kg wet weight)

Contaminant	SL-01	SL-02	SL-03	SL-04
Methylene Chloride	59	39	59	ND
Ethylbenzene	ND	ND	ND	160
Toluene	ND	ND	ND	23

000414

Refractory Organics (all values PPB, ug/kg, wet weight)

Contaminant	SL-04	SL-02	SL-03	SL-01
Acenaphthene	100,000	ND	780.	ND
Acenaphthylene	3,000	ND	2400.	ND
Anthracene	240,000	ND	12000.	ND
Benzo(a)anthracene	17,000	ND	32000.	200.
Benzo(a)pyrene	4,600	ND	21000.	ND
3,4-benzofluorathene	10,000	ND	46000.	260.
Benzo(g,h,i)perylene	ND	ND	7200.	ND
Benzo(k)fluoranthene	10,000	ND	46000.	260.
Chrysene	11,000	ND	42000.	200.
Fluoranthene	260,000	ND	120000.	ND
Fluorene	80,000	ND	980.	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	7200.	ND
Naphthalene	340,000	ND	1000.	ND
Phenanthrene	240,000	ND	2000.	ND
Pyrene	170,000	ND	110000.	10.
Di-n-octyl phthalate	ND	11	ND	ND

Toxic Metals and Inorganics (all values PPM, mg/kg, wet weight)

Contaminant	SL-04	SL-02	SL-03	SL-01
Arsenic (As)	0.35	2.5	82.0	1.8
Beryllium (Be)	0.29	ND	0.20	0.26
Cadmium (Cd)	0.88	ND	0.10	ND
Chromium (Cr)	12.0	7.6	79.0	14.0
Copper (Cu)	4.4	32.0	21.0	ND
Lead (Pb)	8.4	31.0	54.0	3.4
Mercury (Hg)	0.005	0.009	0.040	0.020
Nickel (Ni)	8.6	33.0	2.7	2.3
Silver (Ag)	0.7	ND	0.20	ND
Thallium (Tl)	ND	ND	0.10	ND
Zinc (Zn)	14.0	40.0	290.0	150.0

Discussion of Analytical Results. The previously identified disposal areas, particularly SL-03 are highly contaminated with both polynuclear aromatic hydrocarbons and toxic metals at the surface. The ability of this material to meet the requirements of the EP toxicity test (SW-846 Method 3510 and 8080) even after onsite treatment (biological, incineration) is questionable because of the high toxic metal assay. The high concentration of Pb and As at these locations would probably preclude any disposal option except in a secure landfill (Class I).

Other on site areas surveyed during the surface soils sampling program SL-01 and SL-02 showed minimal organic contamination. There is some evidence of toxic metal contamination (Pb, Cu, Ni >30 PPM) in the southeast quandrant of the site.

000416

6.6 Subsurface Soil Sampling

Objectives. Subsurface soil samples were collected to characterize the depth of contamination and the structure of the underlying soils. No off-site locations were sampled, however, it is assumed that the underlying soil structure on-site is in conjunction with that off-site. The majority of these sampling locations are located at either areas suspected of containing contamination or location of future building foundations and areas of extensive excavation.

Sampling Procedures. A total of seventy-one (71) samples at sixteen (16) locations were collected using both phases of the field investigation at Cavalcade Yard. Initially a total of thirty-two (32) samples were collected at three (3) locations during the first phase. The second phase consisted of another forty-eight (48) samples being collected and an additional thirteen (13) locations. Another ten (10) sampling locations were identified although the procedures could not be carried out because of site access problems. The sampling internal consisted of continuous samples from ground surface to 10' below ground surface than at 5' intervals to 40 feet. For shallow depth holes (10') samples were collected at 2', 6' and 8' depths below the ground surface. Samples were collected using rotary drilling equipment and attaching a 3" thin wall 2' long Shelby tube to the bottom of the drill string and pressing the tube into the soil at the bottom of the bore hole. These samples were removed from the drill string, the soil extruded, trimmed of 1/2" - 1" of the outer skin and ends, examined, described, sectioned, and bottled as appropriate. All sampling equipment was cleaned before reuse. All quality assurance, personal protection, and chain-of-custudy/documentation procedures includd in the Site Specific Health and Safety/Sampling and anlaytical Plan for the Cavalde Yard Site (Appendix II) were followed during this sampling activity. Boring logs were collected during all sampling activities. The analysis of these samples in conjunction with the surface samples were used to provide a complete description of the chemical characteristics of the soil and contamination at this site.

Sample Identification. Each subsurface soil sample collected was recorded by the method identified in the site specific plan contained in Appendix I. A summary of all samples and locations are presented on Table 6.6. Sampling location log sheets are also presented for each sample location in Appendix II.

Summary of Analytical Results. During the subsurface boring program the following compounds were encountered on-site at concentrations above detection limits specified by the analytical technique utilized. Data for each sampling location is presented separately. The depth of boring advancement in feet from the surface is indicated by the number in parenthesis.

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SL-03 (All organic values PPB, ug/kg, all inorganic values PPM, mg/kg wet weight basis)

Volatile Organic Contaminants	01 (2)	02 (5)	03 (10)
Methylene chloride	59	40	33

Refractory Organic Contaminants

Acenaphthene	780.	ND	ND
Acenaphthylene	2400.	280.	ND
Anthracene	12000.	1000.	ND
Benzo(a)anthracene	32000.	5600.	ND
Benzo(a)pyrene	21000.	2000.	ND
3,4-Benzofluoranthene	46000.	6800.	ND
Benzo(g,h,i)perylene	7200.	1600.	ND
Benzo(k)fluoranthene	46000.	6800.	ND
Chrysene	42000.	4500.	ND
Fluoranthene	120000.	24000.	ND
Fluorene	580.	ND	ND
Indeno(1,2,3-c,d)pyrene	7200.	1800.	ND
Naphthalene	1000.	ND	ND
Phenanthrene	20000.	5800.	ND
Pyrene	110000.	20000.	ND

SL-03	01 (2)	02 (5)	03 (10)
Toxic Metal Contaminants			
Arsenic (Ar)	82.0	1.5	0.33
Beryllium (Be)	0.20	0.20	0.20
Cadmium (Cd)	0.10	ND	ND
Chromium (Cr)	79.0	14.0	3.4
Copper (Cu)	21.0	1.9	1.3
Lead (Pb)	54.0	7.2	7.2
Mercury (Hg)	0.040	0.620	0.009
Nickel (Ni)	2.7	3.0	2.1
Silver (Ag)	0.20	ND	0.88
Thallium (Tl)	0.10	ND	ND
Zinc (Zn)	290.0	23.0	3.6

SL-04 (all organic values PPB, ug/kg, all toxic metal values PPM mg/kg, wet weight basis)

Volatile Organic

Contaminants	01 (2)	02 (5)	03 (10)	04 (15)
Ethylbenzene	160	98	10	ND
Methylene chloride	ND	52	73	ND

Refractory Organic Contaminants

Acenaphthene	100000.	360000.	80000.	540.
Acehaphthylene	3000.	ND	3200.	ND
Anthracene	240000.	520000.	48000.	580.
Benzo(a)anthracene	17000.	27000.	28000.	320.
Benzo(a)pyrene	4600.	7600.	32000.	460.
3,4-Benzofluoranthene	10000.	16000.	7200.	340.
Benzo(g,h,i)Perylene	ND	ND	5000.	ND
Benzo(k)fluoranthene	10000.	16000.	7200.	340.
Chrysene	11000.	20000.	36000.	320.
Dibenzo(a,h)anthracene	ND	ND	5000.	ND
Fluoranthene	260000.	440000.	120000.	2000.
Fluorene	80000.	110000.	64000.	340.
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND
Naphthalene	340000.	640000.	200000.	ND
Phenanthrene	240000.	1100000.	180000.	4400.
Pyrene	170000.	280000.	88000.	1400.
2,4-Dimethylphenol	ND	ND	ND	ND
SL-04				

Toxic Metal Contaminants	01 (2)	02 (5)	03 (10)	04 (20)
Arsenic	1.8	2.0	1.2	0.29
Beryllium	0.26	0.28	0.6	0.31
Cadmium	ND	ND	0.5	ND
Chromium	14.0	4.1	8.1	3.7
Copper	ND	0.56	7.7	1.2
Lead	3.4	0.37	9.1	6.4
Mercury	0.020	0.005	0.004	0.005
Nickel	2.3	3.70	15.0	4.50
Silver	ND	ND	1.2	ND
Zinc	15.0	23.0	24.0	5.8

Discussion of Analytical Results. Although the previously identified disposal areas are highly contaminated with both organic and inorganic compounds at the surface, the contamination is attenuated with depth. At sampling location SL-03 the bottom most sample (10 ft) is free of any significant organic or inorganic contamination.

The decrease in concentration from the surface to the bottom of the boring is a factor of 100 for many of the polynuclear-aromatic hydrocarbons and volatile organic compounds. The concentration of Zn (the most significant inorganic contaminant) is attenuated by a factor of almost 30 from the surface to the bottom of the boring.

These findings indicate that once these contaminated materials are excavated and removed from the site the most significant source of groundwater contamination for this site will be gone.

000420

6.7 Shallow Groundwater Sampling

Objectives. Groundwater samples were collected to determine the extent of contamination in the upper groundwater aquifer present beneath the site. No off-site locations were sampled to determine if any contribution to contamination from off-site locations were occurring. Sample locations were identified to; (1) determine the direction of flow of the groundwater and (2) the degree of groundwater contamination adjacent to known waste disposal areas.

Well Installation Procedures. A total of twelve (12) shallow groundwater wells were installed at specified locations throughout the site. An additional well was scheduled to be installed but site access problems prevented installation. The procedures for monitoring well installation started with the use of drilling a 5" diameter hole by hydraulic rotary methods.

Cuttings produced during drilling were monitored to determine strata interface and thickness. Screens that were 2" diameter and 5' long were set below the water bearing sand layer between 6" and 1'. Most screens were set between 15 to 18 feet below the ground surface. The wells were then backfilled with clean sand to the top of the sand layer, sealed with bentonite and then the remainder of the bore hole annuals with cement/grout mixture. A protective pipe was used to cover the hole and the well was developed by pumping water from it for 15-20 minutes until clear. A more detailed description of shallow groundwater monitoring well installation procedures employed at the Cavalcade Yard site are contained in the site specific sampling plan.

Well Sampling Procedures. Only five (5) shallow groundwater monitoring wells were sampled at the site. The sampling procedures consisted of opening the observation well, pumping between five (5) and ten (10) well volumes of water from the well and sampling the water with a stainless steel and Teflon bottom filling bailer. All sampling and well installation downhole equipment was cleaned between locations to protect against cross contamination.

Sample Identification. Each shallow groundwater sample collected at the Cavalcade Yard site was recorded by the method identified in the site specific sampling plan. A summary of all shallow groundwater wells installed and sampled are presented on Table 6.7. Sample location log sheets for each well installation location are also presented in Appendix II.

Summary of Analytical Results. During the upper aquifer groundwater sampling program the following compounds were encountered on site at concentrations above detection limits specific by the analytical techniques utilized.

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Volatile Organics (all values reported as PPB, ug/l)

Contaminants	OW-01	OW-02
Benzene	ND	21
Ethylbenzene	ND	58
Toluene	ND	110

Refractory Organics (all values reported as PPB, ug/l)

Contaminants	OW-01	OW-02
2,4-Dimethylphenol	ND	680
Pentachlorophenol	ND	66
Phenol	ND	59
Acenaphthene	49	380
Acenaphthylene	17	30
Benzo(a)pyrene	NA	29
Bis(2-ethylhexyl) phthalate	ND	17
Butyl benzyl phthalate	ND	17
Di-n-butyl phthalate	ND	34
Fluoranthene	23	34
Fluorene	73	300
Naphthalene	670	17000
Phenanthrene	160	240
Pyrene	17	27

Toxic Metals and Inorganics (all values reported as PPM, mg/l)

Contaminant	OW-01	OW-02
Arsenic (As)	ND	0.13
Copper (Cu)	0.06	ND
Zinc (Zn)	0.12	0.20
Total Cyanide (Cn)	0.70	0.10

Discussion of Analytical Results. The organic contamination observed in the upper (shallow) aquifer is consistent with the surfical contamination associated with past disposal practices at this site with the exception of the volatile organics compounds observed in OW-02. These aromatic hydrocarbons in the ratio detected are consistent with recent petroleum hydrocarbon (gasoline) contamination.

The levels of toxic metals observed in the upper aquifer are at or near EPA primary and secondary drinking water standards and pose no significant threat to health or the environment. It is encouraging to note the high levels of toxic metal contamination encountered in the surface soil samples are not reflected in the associated groundwater sample indicating that these metallic compounds are not in a mobile form in the soil.

The cyanide concentrations observed in wells OW-01 and OW-02 are inconsis- t[illegible] known industrial source on this site. The presence of this compound in the groundwater sampled indicates there may be an off-site [illegible] compounds.

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7.0 ENVIRONMENTAL SITE EVALUATION

The Environmental Site Evaluation presents the general air, soil, and groundwater quality findings at the proposed Cavalcade Yard site. Information and conclusions contained in this section are based on the data obtained from the Phase 1 and Phase 2 site investigation programs. Our recommended additional studies necessary to finalize the Phase 2 investigation and design analysis are outlined in Chapter 9.

7.1 Introduction

As discussed in Section 3.3, creosote waste products were encountered by McClelland Engineers during the Cavalcade Yard Reconnaissance Study. The preliminary Phase 1 investigation of the site was conducted to ascertain whether the site is contaminated and if so to provide a basis for determining what additional work was necessary. Further work was conducted during the Phase 2 investigation to obtain information on subsurface contamination especially in the area of proposed building locations.

7.2 Air Quality

Air emissions from the Cavalcade Yard site produces no significant impact to contiguous areas. The site, located in greater Houston (Harris County), has an air quality consistent with other areas of the city. The site location is in an area classified as nonattainment (not presently meeting national ambient air quality standard - NAAQS) for both ozone and total suspended particulates. The Greater Houston area is classified as being in attainment for sulfur dioxide, nitrogen oxides and carbon monoxide. The existing trucking operations may contribute in small quantities to the nitrogen oxides and carbon monoxide levels.

Presently, no direct sources of air contamination from the previous creosoting and wood preserving operations exist. **All potential disposal and operations areas are presently covered with fill or vegetation.** This provides a barrier which prevents direct contact between these potential sources and the air. Although waste products from this site contain odorous compounds that would degrade ambient air quality, this barrier prevents diffusion of these compounds into the ambient atmosphere. Only upon exposure of the underlying contaminated soils through investigation and/or construction activities could air quality degradation in the immediate area possibly occur. As discussed previously, the waste creosote products disposal at this site have been subjected to environmental degradation and as a result only refractory non-volatile compounds remain. As a result, no major concentrations of volatile organics which might influence the ambient atmosphere were detected. These compounds would not result in a signficant impact to local or regional air quality.

7.3 Sediment and Surface Water Contamination

Analytical results from sediment samples indicate some trace contamination but no significant health hazard. **Concentrations of creosote products range as high as 109 ppm in the drainage ditch adjacent to the railroad on**

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the east side of property (Sample Location CAV-SD-04). This may be related to spillage along the railroad rather than to the prior wood treating and preserving activities. Elsewhere (Sample Locations CAV-SD-01, CAV-SD-02, and CAV-SD-03) concentrations of creosote products in the ditch sediments range from 7.6 to 10.4 ppm, confirming there is localized overt contamination of the drainage ditches.

There appears to be little contamination of surface water at the site. Creosote products are not particularly soluble and high concentrations in water are not expected. The 0.1 ppm of creosote products found in the ditch adjacent to the railroad (Sample Location CAV-SW-01) is probably related to floating oil and spillage along the tracks.

Concentrations of volatile and other organics found in the surface water and sediment samples are not significant. The only volatile organic found, methylene chloride and the only refractory organic found, dibutylphthalate, are both common laboratory contaminants. In contrast, the levels of heavy metals found in the sediment are cause for some concern because they may exhibit hazardous waste leaching characteristics (Extraction Procedure Toxicity). No significant toxic metals were detected in the surface water.

7.4 Shallow Groundwater and Soils Contamination

Visual and analytical data from the three soil borings and five observation wells completed during the Phase 1 investigation indicate that the shallow aquifer and subsurface soils underlying the site contain waste products from creosoting and wood preserving operations. The shallow aquifer consists of silty sand and fine sand and generally occurs within 10 feet below ground surface (see Section 5.2). Relatively high concentrations of creosote products, certain volatiles and other organics were found in samples of the shallow groundwater. No groundwater samples were analyzed from the remaining seven observation wells installed during Phase 2 because of property access problems. Concentrations of creosote products in soil samples at sample locations CAV-SL-03 and CAV-SL-04 range as high as 1,485 ppm at the surface and as high as 2,547 about 10 feet below the surface.

No critical health and safety hazard is indicated under the present site conditions. The State regulatory position, with respect to protection of groundwater quality and hazardous waste management, considers it essential to ascertain the nature and extent of the groundwater system and the potential for off site migration.

Water level measurements in the nine shallow observation wells on the Cavalcade Yard site and three shallow observation wells installed north of the Cavalcade Street show a consistent east to west hydraulic gradient, averaging about 20 feet per mile (see Plate 7-1). The influence on groundwater gradients exerted by the active waste disposal lagoon at the acetylene manufacturing plant east of the site is evident from the westward direction of the groundwater contours. Temporal fluctuations in the elevation of the water table, the shallow depth to the water table along the east side of the property, and the trend of water level contours suggest that the predominant area of recharge is a short distance east of the site and not confined to a single point source; i.e., the acetylene plant. In general, the groundwater is under unconfined conditions. The presence of fine-grained materials (clays and silts) in the upper parts of most of the aquifer, however, serves to partially confine the groundwater, particularly under short-term conditions.

The configuration of the water table and the east to west direction of groundwater flow is not consistent from what would be inferred from consideration of topography in the vicinity of the Cavalcade property and the locations of the drainage ditches into which shallow groundwater would discharge (Plate 5-4). The Cavalcade Yard site lies in the drainage basin of Hunting Bayou. As discussed in Section 5.4, the land surface in the vicinity of the site slopes gently to the southeast and east toward Hunting Bayou. A shallow ditch, draining into a branch of Hunting Bayou, lies only about 500 feet north of the property. Another branch of Hunting Bayou, abut 10 feet deep, lies just over a half-mile east of the site. A drainage swale from the branch extends along Collingsworth Street to the south. Little White Oak Bayou is the nearest major drainage course on the west. But at a depth of 25 feet, it is also the deepest Bayou in the vicinity of the site. The drainage divide between Hunting and Little White Oak Bayous is oriented to the southeast and passes southwest of the site.

A projection of the groundwater surface beneath the Cavalcade Yard site (at a gradient of 20 feet per mile to the west) to Little White Oak Bayou would just intersect the bottom of the closet proximity to the Bayou. But the projected surface would cross the drainage divide between Hunting and White Oak Bayous. While topographic and groundwater divides need not coincide, such a wide discrepency in orientation and position is unusual.

Because of its greater recharge potential, it is possible that a sandfilled channel (Pleistocene distributory channel) lying just east of the site and extending approximately north-south is influencing the water table configuration more than surface drainage. No channel is shown on available detailed geologic maps, but it might easily have been missed or excluded because of its small size and the extensive urbanization of the area. It is also possible that the current configuration and gradient of the shallow water table is not natural but is being influenced by artificial or transient sources east of the site. The data are insufficient to confirm this.

The only information available on the extent of contamination in the shallow aquifer at the proposed Cavalcade Yard site is the analysis performed for Observation Wells CAV-OW-1 and CAV-OW-2 and the visual and odor observations made during drilling of the seven additional shallow observation wells. This information indicates that:

- Shallow groundwater in the vicinity of CAV-OW-02 is contaminated with creosote waste products. The concentration of the creosote products was 18 ppm. Volatile organics, including benzene, toluene and ethylbenzene which are typical of petroleum products, and some other organics including pentachlorophenol were also found.

- Groundwater from CAV-OW-01 is also somewhat contaminated. The concentration of cyanide, however, suggests that at least some of the contamination is contributed by seepage from the waste disposal lagoon of the acetylene plant located to the east.

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- Shallow groundwater and soils in the vicinity of observation wells CAW-OW-10, CAV-OW-11, CAV-OW-13, and CAV-OW-14 also appear to be contaminated. CAV-OW-10 as clearly the most contaminated, CAV-OW-13 is the least contaminated.

Contamination of groundwater from CAV-OW-02 is related to the high levels of creosote waste products found in soil borings CAV-SL-03 and CAV-SL-04. Based on analyses of aerial photographs, it appears that the area near observation well CAV-OW-02 could potentially be a previous waste disposal area. This area has been subsequently disturbed and its boundaries and exact location are obscured. **The high degree of contamination indicated at well CAV-OW-10 suggests that this well also is in or adjacent to another major source of creosote waste products.** Data are insufficient, however, to define the nature of this source.

The distribution of the shallow groundwater contamination indicated by the other shallow observation wells is not entirely consistent with the groundwater flow regime. Except for well CAV-OW-10, all the wells in which contamination was detected are located on the upgradient (east) side of the property. As stated earlier, some of the contamination of well CAV-OW-01 is from the waste disposal lagoon at the acetylene plant east of the Cavalcade Yard site.

The probable presence of creosote waste products in observation wells CAV-OW-01, CAV-OW-11, CAV-OW-13, and CAV-OW-14 suggests either that the source is off the property; e.g., spillage along the railroad tracks east of the property, or that the present flow system is not the same as existed in the past when wood treating and preserving operations were active on the site. **It does not appear, however, that under the present groundwater flow regime that any of the contaminants are being transported offsite as determined by observation wells CAV-OW-08 and CAV-OW-09, except possibly at the southwest corner of the Cavalcade Yard site.** Considering the age of the wastes products and that the more volatile and mobile compounds would have already left the site, this is not unexpected.

Because the data do not appear entirely consistent and because Phase 2 work was not completed, it is difficult to assess the full impacts of past use of the Cavalcade site on the shallow groundwater. There are one or more places on the site which are serving as "sources" of contamination. Material excavated from these places are expected to reduce future groundwater contamination of the shallow aquifer. The site does not, however, appear to be contributing extensively to pollution of the shallow groundwater in the vicinity of the site.

7.5 Deep Groundwater

Because indications of contamination from creosote waste products were found at 40 ft below ground surface in soil borings CAV-SL-03 and CAV-SL-04, and because of the shallow groundwater contamination, Texas Department of Water Resources (TDWR) requested the installation of a deep (200 ft) observation well. The purpose of the deep well was to ascertain whether contamination from the wood treating and preserving operations at the Cavalcade Yard site had migrated downward to the first usable aquifer. As discussed in Section 5.5, the first usable aquifer was taken to be the

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shallowest aquifer known to yield water for domestic purposes. It was assumed that because yield requirements from domestic wells are very small and because of cost considerations, domestic users will tap the shallowest possible aquifer which is capable of yielding water of a suitable quality for a sustainable period. In the vicinity of the Cavalcade Yard site, the shallowest aquifer known to be used for domestic purposes is about 200 feet below the ground surface.

The deep observation well, CAV-GW-06, was installed to the southeast of soil borings CAV-SL-03 and CAV-SL-04. The specific location was chosen because:

a) It was close to, and presumably downgradient, from the suspected disposal area.

b) It was outside the inferred boundary of waste disposal area, thus reducing the possibility of drilling through buried wastes and inadvertently carrying contaminants downward.

c) It was outside the boundaries of any planned structures, reducing the possibility that the well would be destroyed during construction.

Installation and sampling procedures were developed according to detailed specifications (see Section 6.3). During drilling, all soil samples recovered were examined visually and analyzed with an HNU photoionzier. Soil samples immediately above and below the target aquifer were assigned a complete priority pollutant analysis. A groundwater sample was collected after the well had been completely developed by pumping for several days to permit a representative sample. A complete priority pollutant analysis was also assigned for the groundwater sample.

No visible contamination or odor was detected below about 60 feet. HNU readings continued to be high (2000 ppm) to as deep as 112 feet and as high as 400 ppm into the target aquifer. Priority pollutant scans of the soil samples above and below the target aquifer showed no detectable contamination. **Analysis of the groundwater sample revealed that toluene (49 ppb) was the only contaminant present that is possibly related to wood treating and preserving operations (49 ppb).**

The available data suggest that groundwater in the "200 foot" aquifer has not contaminated by wood treating or preserving operations on the Cavalcade Yard site and most likely has not been contaminated in the past. **The presence of toluene**, in the absence of other organic contaminants in both the well samples and soil boring samples collected during the installation of the well, is anomalous and in **our opinion probably represents a contaminant introduced from some source other than the site.** Similarly, the high HNU readings appear to anomalous. The HNU device is a generic detector and simply responds to photoionizable compounds with a disassociation energy equal to or less than ultraviolet lamp source, 10.2 eV. HNU readings are not specific to creosote wastes or even organic molecules. The specific cause of the high HNU readings observed during the installation of the well is not known. These values could be a result of any number of causes including, a response to naturally occurring organic compounds or a transient instrument malfunction. The cause of this anomaly should be

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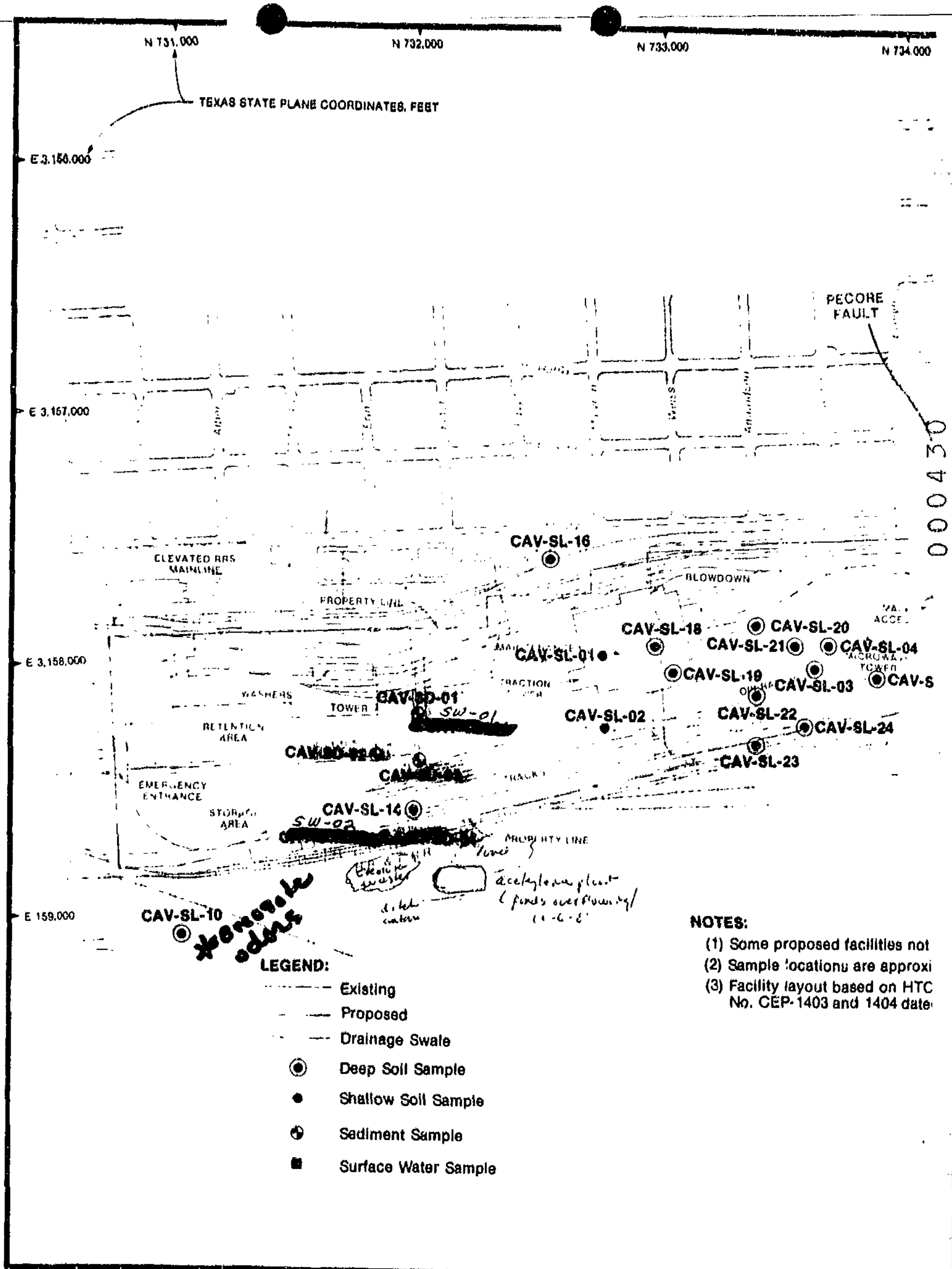
determined when the field studies are completed. In summary, it is our opinion that the deep well sample should be retaken and analyzed and if our judgment holds and the "deep" aquifer is not contaminated then the site development in accordance with the recommended Remedial Action Plan should proceed.



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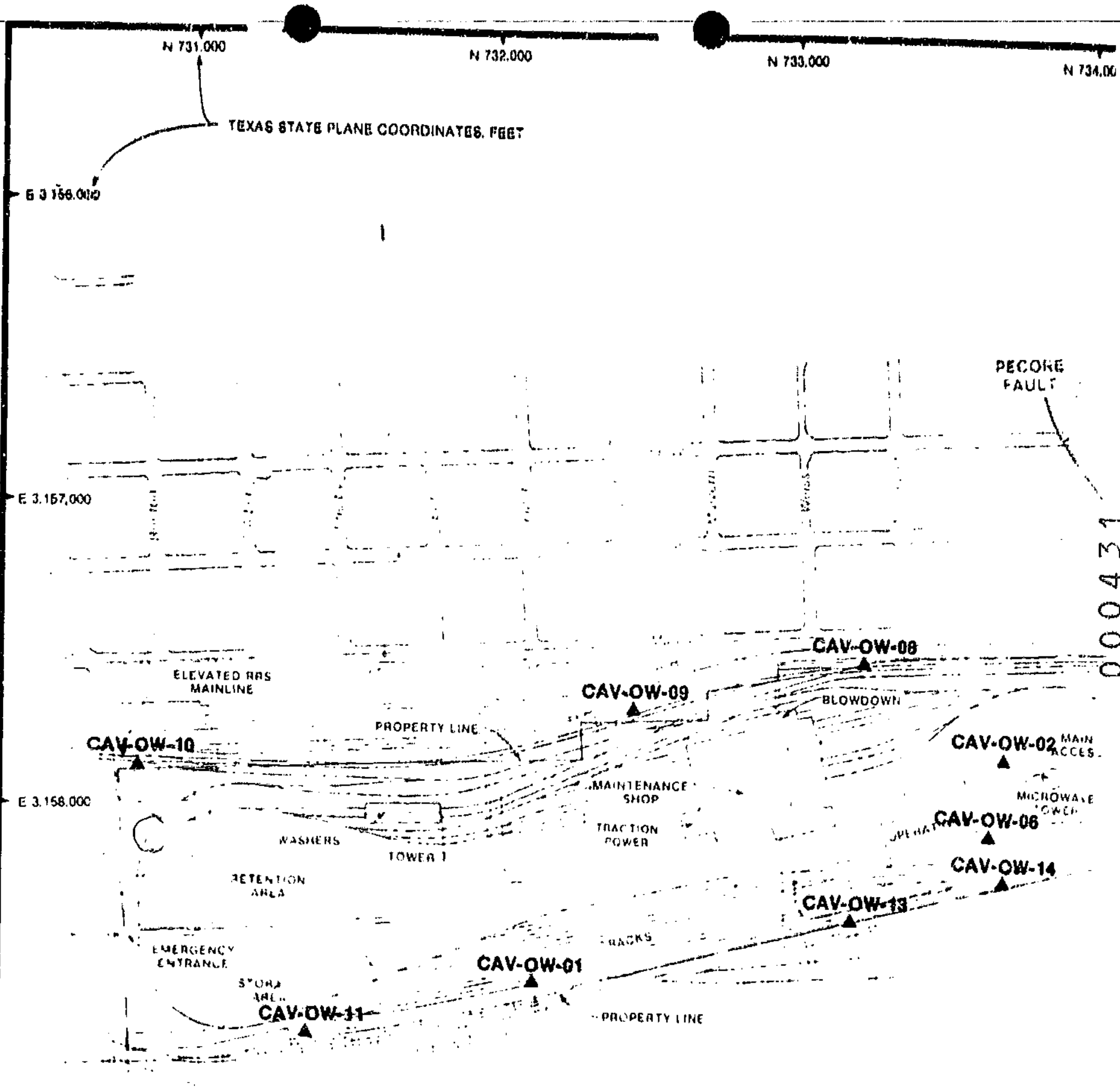

LEGEND:

- Existing
- Proposed
- Drainage Swale
- ▲ Observation Well

NOTES:

(1) Some proposed facilities n

(2) Boring locations are appro

(3) Facility layout based on H
No. CEP-1403 and 1404 da

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Attachment 3: Summary of Creosote Operations & Characteristics

Narrative

Creosote treatment for wood preservation historically has involved pressure vessels, storage tanks, pole yards, and treatment ponds. Steam and vacuum operations would draw sap out of poles and creosote "oil" would be pressured into the pole or sometimes dipped without pressure. During the 1920's and 1930's, ponds were typically used for recovery of creosote "oil" which would sink to the bottom of the ponds. Later operations might use pentachlorophenol which would float on the ponds. As a part of "historical" pond closure, the bottom sludges would spread in earth moving operations. The term creosote denotes a chemically complex mixture as delineated in the following tables.

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TABLE 1

COAL TAR FRACTIONS

FRACTION	BOILING TEMP (°C)	COMPOUNDS
Light Oil	<200	Benzene Toluene Xylene Heavy Solvent Naphtha
Naphthalene Oil	200-250	Tar Acid-Phenol, Cresols, Xylenols Tar Bases-Pyridine Naphthalene
Heavy Oil	250-300	Methylnaphthalenes Dimethylnaphthalenes Acenaphthene
Anthracene Oil	300-350	Fluorene Phenanthrene Anthracene Carbazole
Pitch	>350	Gas Heavy Oil Red Wax Carbon

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TABLE 2

PRINCIPAL CONSTITUENTS OF HIGH-TEMPERATURE CREOSOTE (1)

COMPOUNDS	% BY WEIGHT
Naphthalene	7-28
Phenanthrene	9-14
Acenaphthene	2-5
Fluoranthene	2-5
Fluorene	2-4
Methylnaphthalenes	1-4
Pyrene	2-3
Carbazole	1.8-2.7
Anthracene	1.2-1.8
Dibenzofuran	0.5-1.0

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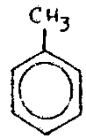
1. Nicholas, Darrel D., Ed, Wood Deterioration and its Prevention by Preservative Treatments, Volume II, Syracuse University Press, 1973.

Log Octanol water

CREOSOTE COMPOL

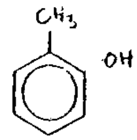
→ Log Kow (Solu. in H_2O @ 20°C-mg/L)

BENZENE
2.13 (1780)

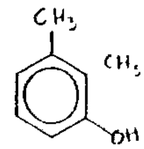


TOLUENE
2.69 (535)

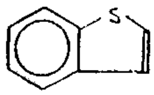
PHENOL
1.46 (93000)



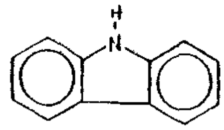
CRESOLS



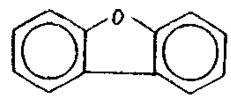
XYLENOLS



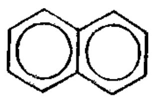
BENZOTHIOPHENE
~2.21 (0.13)



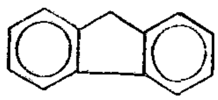
CARBOZOLE
~2.80 (0.001)



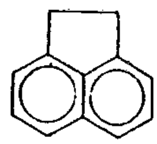
DIBENZOFURAN
~4.21 (   )



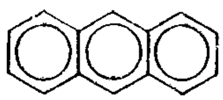
NAPHTHALENE
3.37 (34)



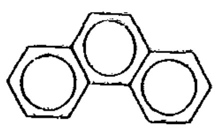
FLUORENE
4.18 (1.8)



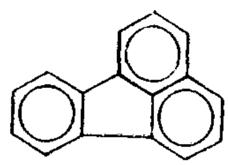
ACENAPHTHENE
4.33 (3.42)



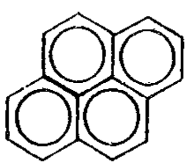
ANTHRACENE
4.45 (0.045)



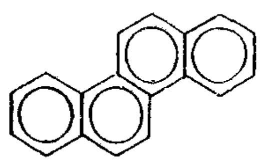
PHENANTHRENE
4.46 (1.1)



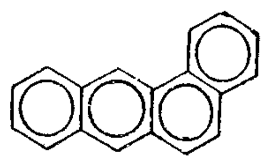
FLUORANTHENE
5.33 (0.26)



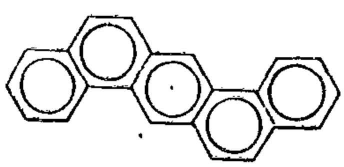
PYRENE
5.32 (0.14)



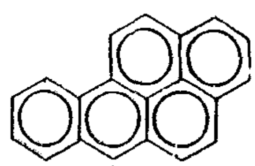
CHRYSENE
5.61 (0.002)



BENZO[a] ANTHRACENE
5.61 (0.01)



DIBENZO[a,h] ANTHRACENE



BENZO[a] PYRENE

000435

Attachment 4

Cavalcade Yard Waste Volume

Analysis of aerial photography for the period of concern reveals at least three distinct waste pits in addition to contaminated areas of product storage.

The waste pits are conservatively estimated as shown below:

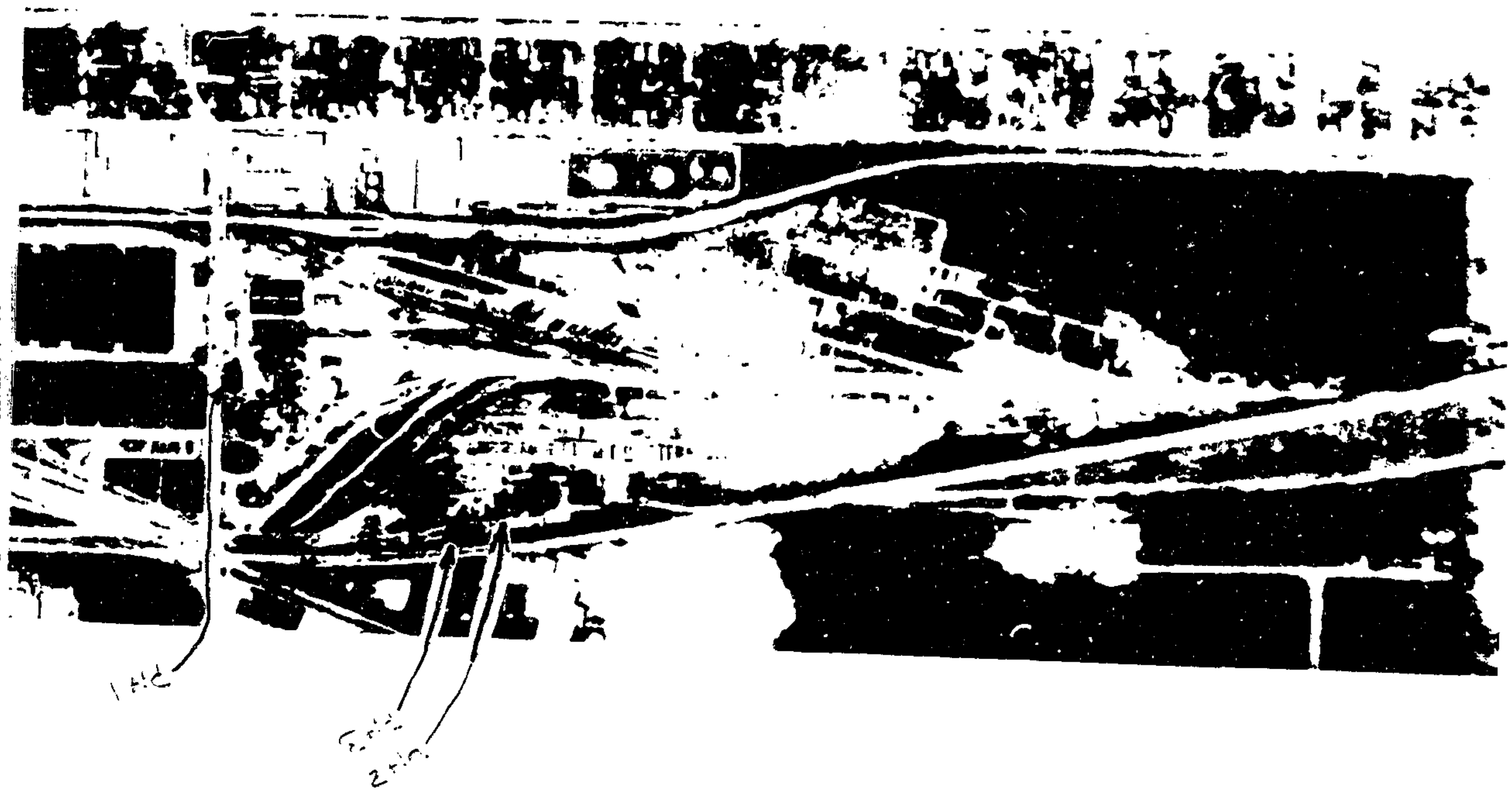
Pit #1	50 x 100	= 5,000
Pit #2	30 x 50	= 1,500
Pit #3	30 x 70	= 2,100

Total pit area from aerial photography = 8,600 ft.^{2}

Depth of waste sludges is conservatively estimated at 2'. Thus, waste volume is at least:

$$\frac{(8,600) \times (2)}{27} = 637 \text{ yd}^3$$

000436

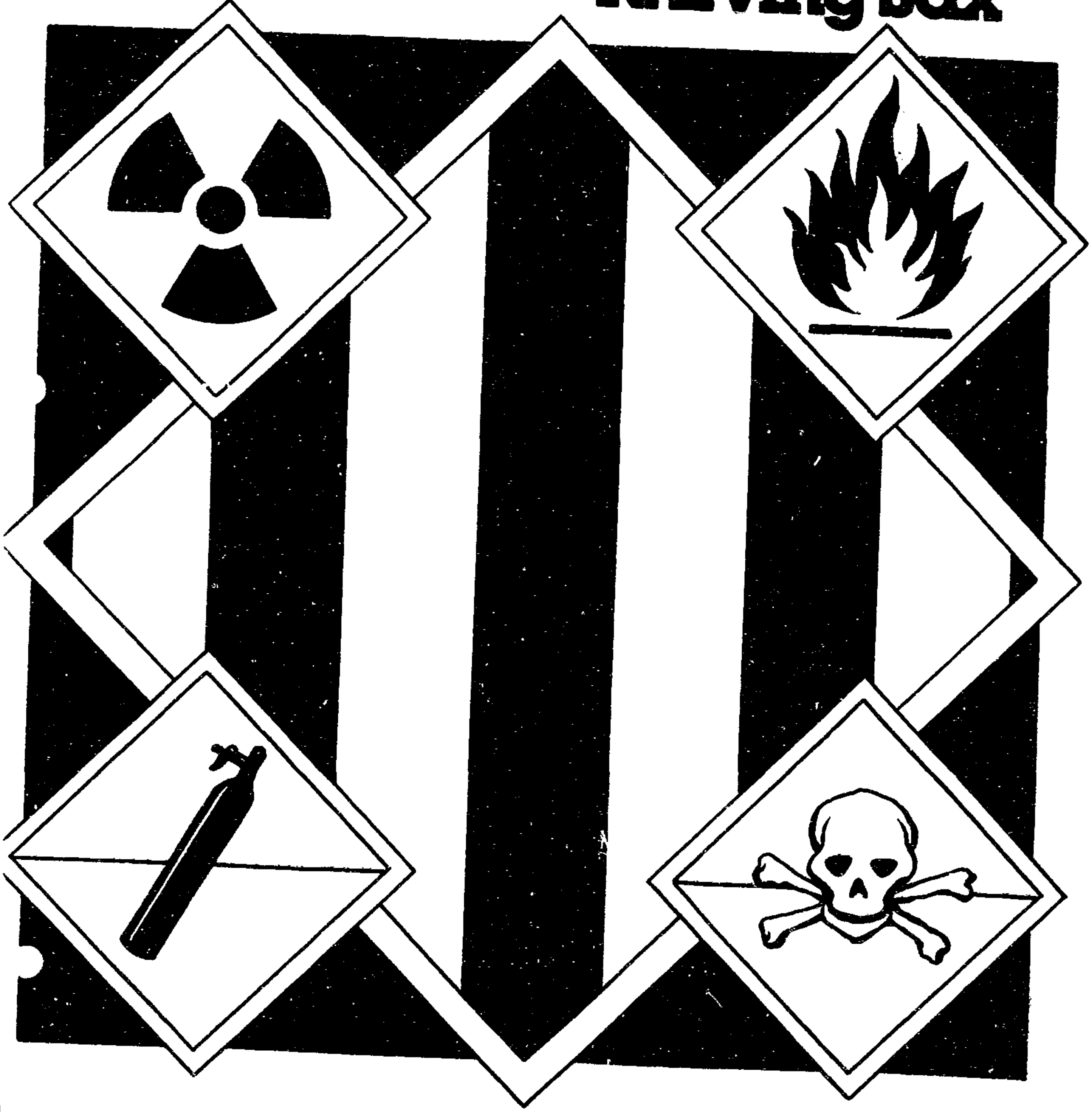


000437

Dangerous Properties of Industrial Materials

Fifth Edition

N. Irving Sax



000438

ZOIC ACID ANHYDRIDE. See benzoic anide.

ZOIC ACID-α-METHYLBENZYL ESTER. See iethylbenzyl benzoic acid.

ZOIC ALDEHYDE. See benzaldehyde.

ZOIC ANHYDRIDE. Syn: *benzoic acid anhyle.* Crystals. $(C_6H_5CO)_2O$, mw: 226.2, mp: 42°, 360°, d: 1.1989 @ 15° 4°, vap. press: 1 mm @ .6°.
R = A MILD irr and allergen.
e Hazard: Slight, when heated.

ZOL. See benzene.

ZOL DILUENT. Flash p: −25°F, autoign. temp.: 0°F (these values will vary depending on the anufacturer).
HR = U.
re Hazard: Dangerous, when exposed to heat or flame or powerful oxidants.
o Fight Fire: Alcohol foam, water mist, fog, dry chemical.

ZO(a)NAPHTHO(2,1,8-hi j)NAPHTHACENE.
HR = An exper carc. [*23*]

NZO(a)NAPHTHO(8,1,2-cde)NAPHTHACENE.
$C_{28}H_{16}$, mw: 352.4.
HR = An exper neo. [*3, 23*]

NZO(h)NAPHTHO(1,2,f)QUINOLINE. $C_{21}H_{13}N$, w: 279.4.
HR = An exper neo. [*3, 23*]

NZO NITRILE. Syn: *phenyl cyanide.* Transparent, olorless oil, almond-like odor. C_6H_5CN, mw: 103.1, : 1.246 @ 20° 4°, bp: 191°, d: 1.0102 @ 15° 15°F OC), mp: −12.8°.
HR = HIGH. See nitriles.

NZO(r,s,t)PENTAPHENE. Green-yellow needles. $C_{24}H_{14}$, mw: 302.4, mp: 280°–282°.
THR = An exper (+) neo and carc. [*3, 11, 23*]

NZO(r,s,t)PENTAPHENE-5-CARBOXALDEHYDE. $C_{25}H_{14}O$, mw: 330.4.
THR = An exper neo. [*3*]

NZO(ghi)PERYLENE.
THR = An exper carc. [*23*]

NZO(a)PHENALENO(1,9-hi)ACRIDINE.
$C_{27}H_{15}N$, mw: 353.4.
THR = An exper neo. [*3*]

NZO(h)PHENALENO(1,9-6c)ACRIDINE.
THR = An exper neo. [*3*]

NZO(d,e,f)PHENANTHRENE. See pyrene.

NZO(c)PHENANTHRENE. $C_{18}H_{12}$, mw: 228.3.
THR = An exper carc. [*3, 23*]

BENZO(c)PHENANTHRENE-8-CARBOXALDEHYDE. $C_{19}H_{12}O$, mw: 256.3.
THR = An exper neo. [*3*]

5-BENZO(c)PHENANTHRYL METHYL KETONE. $C_{12}H_{14}O$, mw: 270.3.
THR = An exper carc. [*3*]

BENZO PHENONE. Syn: *phenyl ketone, diphenyl ketone.* Rhombic white crystals, persistent rose-like odor. $C_6H_5COC_6H_5$, mw: 182.21, mp (α): 49°, mp (β): 26°, mp (γ): 47°, bp: 305.4°, d (α): 1.0976 @ 50°/50°, d (β): 1.108 @ 23°/40°, vap. press: 1 mm @ 108.2.
THR = Details U. See also ketones.
Fire Hazard: Slight, when heated; can react with oxidiing materials.

BENZO PYRENE. See benzo(a)pyrene.

BENZO(a)PYRENE. Yellow crystals insol in water, sol in benzene, toluene, xylene. $C_{20}H_{12}$, mw: 252.3, mp: 179°, bp: 312° @ 10 mm.
THR = HIGH. An exper (+) carc, [*3, 11, 23*] neo and mutagen. A common contaminant of air, water, food, smoke.

BENZO(a)PYRENE-6-CARBOXALDEHYDE.
$C_{21}H_{12}O$, mw: 280.3.
THR = An exper neo and carc. [*3*]

BENZO(a)PYRENE-6-CARBOXALDEHYDE THIO SEMICARBAZONE. $C_{22}H_{15}N_3S$, mw: 353.5.
THR = An exper carc. [*3*]

BENZO(a)PYRENE-4,5-EPOXIDE. $C_{20}H_{14}O$, mw: 270.2.
THR = An exper neo to mice via dermal route. [*103*]

BENZO(a)PYRENE-7,8-EPOXIDE. $C_{20}H_{14}O$, mw: 270.2.
THR = An exper neo to mice via dermal route. [*103*]

BENZO(a)PYRENE-6-METHANOL. $C_{21}H_{14}O$, mw: 282.4.
THR = An exper neo and carc. [*3*]

BENZO(a)PYRENE-4,5-OXIDE. $C_{20}H_{12}O$, mw: 268.3.
THR = An exper neo. [*3*]

BENZO(a)PYRENE-7,8-OXIDE.
THR = An exper carc. [*3*]

BENZO(a)PYREN-6-OL. $C_{20}H_{12}O$, mw: 268.3.
THR = An exper neo. [*3*] An exper neo to mice via sc and in routes. [*103*]

7H-BENZO(a)PYRIDO(3,2-g)CARBAZOLE.
$C_{19}H_{12}N_2$, mw: 268.3.
THR = An exper neo. [*3, 23*]

7H-BENZO(c)PYRIDO(2,3-g)CARBAZOLE.
THR = An exper neo. [*3, 23*]

CHROMOUS FLUORIDE. Syn: *chromium difluoride.* CrF_2, mw: 90.01, mp: 1100°, bp: >1300°, d: 4.11.
THR = See chromium compounds. A powerful irr. See fluorides.
Disaster Hazard: See fluorides.

CHROMOUS HYDROXIDE. Yellow-brown crystals. $Cr(OH)_2$, mw: 86.03.
THR = See chromium compounds.

CHROMOUS IODIDE. Grayish powder. CrI_2, mw: 305.85, d: 5.196.
THR = See chromium compounds.

CHROMOUS MONOSULFIDE. Black powder. CrS, mw: 84.08, d: 4.1.
THR = See chromium compounds and sulfides. Reacts violently with F_2, CrO_3. [*19*]

CHROMOUS MONOXIDE. Black crystals. CrO, mw: 68.01.
THR = Self ignites in air. [*19*] See chromium compounds.

CHROMOUS OXALATE. Yellow crystalline powder. $CrC_2O_4 \cdot H_2O$, mw: 158.05.
THR = See chromium compounds and oxalates.

CHROMOUS SULFATE. Blue crystals. $CrSO_4 \cdot 7H_2O$, mw: 274.19.
THR = See chromium compounds.

CHROMYL CHLORIDE. See chromium oxychloride.

CHROMYL FLUORIDE. Exists in 2 modifications; appears first as a reddish-black solid and polymerizes on exposure to light into a dirty white solid, forming reddish-brown vapors on melting. CrO_2F_2, mw: 122.01, mp: 200°.
THR = See chromium compounds.

CHRONIC TOXICITY. See Sections 9 and 1.

CHRYSAROBIN. Syn: *goa powder.* Brownish to orange-yellow crystals. $C_{15}H_{12}O_3$, mw: 240.3.
Acute tox data: ip LD_{LO} (mouse) = 4 mg/kg. [*3*]
THR = HIGH via ip route. An irr and allergen.
Fire Hazard: Slight; when heated, emits smoke.

CHRYSENAMINE. $C_{18}H_{14}N$, mw: 244.3.
THR = An exper carc. [*3*]

CHRYSENE. Syn: *1,2-benzphenathrene.* Crystals, slightly sol in ether, alcohol and glacial acetic acid, insol in water. $C_{18}H_{12}$, mw: 228.2, d: 1.274 @ 20°/4°, mp: 254°, bp: 448°.
THR = HIGH via sc and dermal and probably inhal routes. An exper (+) neo and carc. [*3, 11, 23*] A polycyclic hydrocarbon air pollutant.

CHRYSOIDINE B. $C_{12}H_{12}N_4 \cdot HCl$, mw: 248.7.
THR = An exper (+) carc, neo. [*3, 4*]

CHRYSOPHANIC ACID ANTHRANOL. See chrysarobin.

CHRYSOTILE. It composes 96% of all asbestos. Se asbestos white and asbestos particles.
THR = An exper carc. [*23*]

CHYMOSIN. See rennet.

CI ACID BLUE 9(DISODIUM SALT). $C_{37}H_{36}O_9N_2S$ mw: 795.
THR = An exper neo. [*3*]

CI ACID GREEN 5. $C_{37}H_{36}C_9N_2S_3$, mw: 795.
THR = An exper carc. [*3*]

CICUTA. See coniine.

CICUTINE. See coniine.

CIGAR SMOKE.
THR = A carc. [*14*]

CIGARETTE SMOKE.
THR = A carc. [*14*]

CIMENE. See dipentene.

CINERIN I. Syn: *3-(2-butenyl)-4-methyl-2-oxo-3-cyclo penten-l-yl ester of chrysanthemum monocarboxyli acid.* Viscous liquid. $C_{20}H_{31}O_3$, mw: 319.5, bp: 200° @ 0.1 mm with decomp.
Acute tox data: LD_{50} (rat) = 1050 mg kg. [*3*]
THR = MOD via inhal and oral routes. Large dose can cause diarrhea, convulsions and damage t kidneys and liver; prostration and death from respi ratory paralysis. See also pyrethrin I.

CINERIN II. Syn: *3-(2-butenyl)-4-methyl-2-oxo-3-c clopenten-l-yl ester of chrysanthemum dicarboxyl acid monomethyl ester.* A viscous liquid. $C_{21}H_{28}O$ mw: 360.4, bp: 200° @ 0.1 mm.
THR = U. An insecticide. See cinerin I.
Fire Hazard: Slight, when heated.

CINNABAR. See mercuric sulfide.

CINNAMALDEHYDE. Syns: *cinnamic aldehyde, phenyl propenal, cinnamyl aldehyde.* Yellowish oi cinnamic odor, sol in 5 volumes of 60% alcohol, ver slightly sol in water. $C_6H_5CH{:}CHO$, mw: 115, 1.048–1.052 @ 25°/25°, mp: −8°, bp: 246°.
Acute tox data: Oral LD_{50} (rat) = 2220 mg/kg: ip LD_5 (mouse) = 200 mg/kg. [*3*]
THR = HIGH via ip and MOD via oral and inha routes. Synthetic flavoring substance and adjuvan [*109*]

CINNAMAMIDE. Solid. $C_6H_5CHCHCONH_2$, mw 147.2, mp: 147°.
THR = U. An insecticide.
Fire Hazard: Slight.

CINNAMEIN. See benzyl cinnamate.

CINNAMENE. See phenyl ethylene.

CINNAMIC ACID, SODIUM SALT. White crystallii scales. $C_9H_8O_2 \cdot Na$, mw: 171.2.

ATTACHMENT 5

Harris Galveston Coastal
Subsidence District Records

ANALOG-MODEL STUDIES OF GROUND-WATER HYDROLOGY IN THE HOUSTON DISTRICT, TEXAS

By

Donald G. Jorgensen
U.S. Geological Survey

ABSTRACT

The major water-bearing units in the Houston district are the Chicot and the Evangeline aquifers. The Chicot aquifer overlies the Evangeline aquifer, which is underlain by the Burkeville confining layer. Both aquifers consist of unconsolidated and discontinuous layers of sand and clay that dip toward the Gulf of Mexico.

Heavy pumping of fresh water has caused large declines in the altitudes of the potentiometric surfaces in both aquifers and has created large cones of depression around Houston. The declines have caused compaction of clay layers, which has resulted in land-surface subsidence and the movement of saline ground water toward the centers of the cones of depression.

An electric analog model was used to study the hydrologic system and to simulate the declines in the altitudes of the potentiometric surfaces for several alternative plans of ground-water development. The results indicate that the largest part of the pumped water comes from storage in the water-table part of the Chicot aquifer. Vertical leakage from the aquifers and water derived from the compaction of clay layers in the aquifers are also large sources of the water being pumped.

The response of the system, as observed on the model, indicates that development of additional ground-water supplies from the water-table part of the Chicot aquifer north of Houston would result in a minimum decline of the altitudes of the potentiometric surfaces. Total withdrawals of about 1,000 million gallons (3.8 million cubic meters) per day may be possible without seriously increasing subsidence or salt-water encroachment.

Analyses of the recovery of water levels indicate that both land-surface subsidence and salt-water encroachment could be reduced by artificially recharging the artesian part of the aquifer.

determined by calculating the volume of water in storage in the "zone to be depleted" using a grid spatial count and multiplying by a specific yield of 15 percent. The analysis depended upon leaving enough saturation in the aquifer to maintain transmissibilities of 10,000 (gal/d)/ft or 124,000 (l/d)/m.

Under the assumptions of this study, the average annual ground-water availability, as shown in Appendix A, was determined by dividing the volume of water in recoverable storage by 53 years (January 1, 1977 through December 31, 2029) and then adding this to the annual effective recharge.

Brazos River Alluvium of Southeast Texas

Another aquifer considered as part of the Alluvium and Bolson deposits is the water-bearing alluvium that occurs in the floodplain of the Brazos River of southeast Texas (Figure 6). These stream-deposited alluvial materials, which range from less than 1 mile (1.61 km) to about 7 miles (11 km) wide, supply comparatively large volumes of ground water used principally for irrigation. They extend approximately 350 miles (563 km) along the sinuous course of the river between northern McLennan County and central Fort Bend County (Cronin and Wilson, 1967).

An estimated 1,000 irrigation wells pump from this aquifer with most of the yields ranging from 250 to 500 gal/min (16 to 32 l/s). Saturated thickness of these deposits is as much as 85 feet (26 m) or more with the maximum thickness occurring in the central and southeastern part of the aquifer. The chemical quality of the ground water varies widely, even within short distances. In many areas, concentrations of dissolved solids exceed 1,000 mg/l. The soils of the Brazos River valley irrigated with this ground water are usually sufficiently permeable to alleviate soil salinity problems.

The methodology used to determine the annual effective recharge to this aquifer was principally the comparison of water-level trends and pumpage. On this basis, the total annual effective recharge to the Brazos River alluvium was estimated to be 100,000 acre-feet or 123 hm^3 (Cronin and Wilson, 1967, p. 73). A breakdown of this recharge by zone is shown in Appendix A.

Using data prepared by Cronin and Wilson (1967, p. 73), approximately 1.85 million acre-feet (2,280 hm^3) of fresh to slightly saline ground water was estimated to be in storage in the areas considered. Based on 75 percent of the total storage, approximately 1.38 million acre-feet (1,710 hm^3) is estimated as water recoverable from storage.

The average annual ground-water availability to the year 2030 as shown in Appendix A was calculated by dividing the estimated recoverable storage by 56 years (January 1, 1974 through December 31, 2029) to determine the annual storage depletion rate and then adding this to the annual effective recharge.

In summary, the total estimated annual effective recharge to the Alluvium and Bolson Deposits aquifer in Texas, is 434,000 acre-feet (535 hm^3). This is an increase of 121,200 acre-feet (149 hm^3) or 39 percent over the estimate in the 1968 Texas Water Plan. Due to constraints placed upon the Cenozoic Alluvium to prevent water-quality deterioration, complete development of all the ground water in storage in this aquifer is not feasible and therefore an estimate of total quantity in storage for all of the alluvium and bolsons evaluated throughout the State was not made. About 32.7 million acre-feet (40,300 hm^3), however, is estimated to be recoverable. This is an increase of about 22.9 million acre-feet (28,200 hm^3) or 335 percent over the estimate in the 1968 Texas Water Plan. All increases are due to the inclusion of areas which were not evaluated for the 1968 Plan.

Gulf Coast

Geologically, the Gulf Coast aquifer ranges in age from Miocene to Holocene and, for the purposes of this report, it is considered as composed of the Catahoula, Oakville, Lagarto, Goliad, Willis, Lissie, and Beaumont Formations, as well as overlying surficial deposits. The aquifer consists of alternating beds of clay, silt, sand, and gravel which are hydrologically connected and form a large, leaky artesian aquifer system. Its principal water-bearing units are the Goliad, Willis, and Lissie Formations. The areal extent of the aquifer is shown on Figure 6, and Appendix B lists the water-bearing properties.

Normally, water of better quality, that is, less than 500 mg/l dissolved solids, occurs in the aquifer from the San Antonio River basin northeastward to Louisiana. In this area, usable quality water may be encountered to a maximum depth of 3,200 feet (975 m) below land surface. The maximum total aggregate sand thickness is about 1,300 feet (396 m). Well yields in this portion of the aquifer usually average about 1,600 gal/min (101 l/s). Larger quantities, up to 4,500 gal/min (284 l/s), of fresh to slightly saline water are pumped by some individual wells for municipal, industrial, and irrigation use. However, there are areas in southeastern Chambers

000443

HARRIS GALVESTON COASTAL SUBSIDENCE DISTRICT
1660 WEST BAY AREA BOULEVARD
PHONE 713/486-1105 - FRIENDSWOOD, TX 77546

GENTLEMEN:

DUE TO THE LARGE VOLUME OF REQUESTS FOR WELL DATA, IT HAS BEEN NECESSARY TO STANDARDIZE OUR OUTPUT FORMAT.

THE ENCLOSED PRINTOUT LISTS ALL WELLS WITHIN 3.0 MILES OF THE FOLLOWING POINT BY ASCENDING LATITUDE (I.E. FROM SOUTH TO NORTH):

LATITUDE 29 DEG 47 MIN 30 SEC

LONGITUDE 95 DEG 21 MIN 0 SEC

WE REGRET WE CAN NO LONGER CUSTOMIZE OUR OUTPUT TO INDIVIDUAL SPECIFICATIONS AND HOPE THAT THE ENCLOSED WILL SERVE YOUR NEEDS.

SINCERELY YOURS,

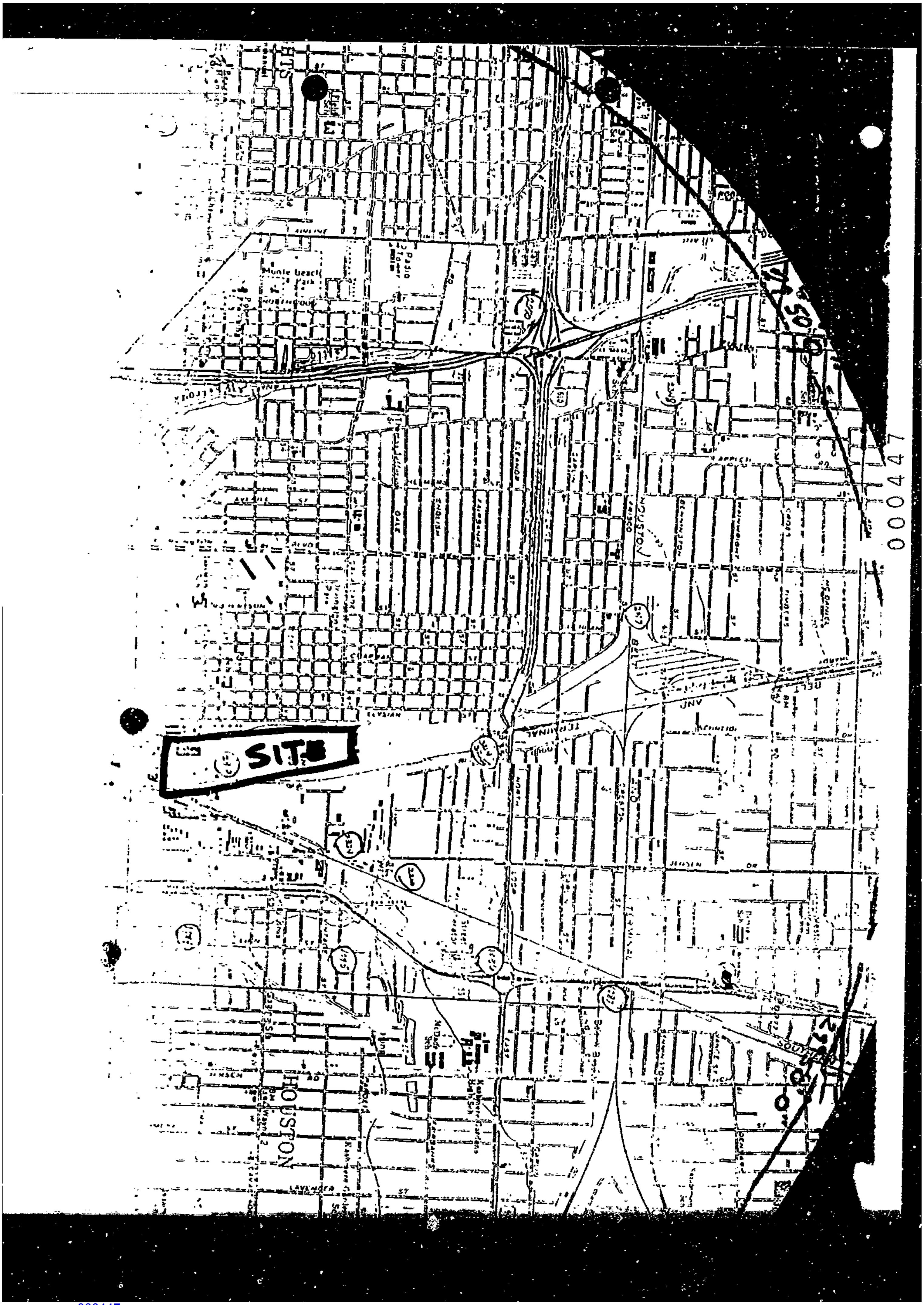
J. C. HOLZSCHUH
SENIOR HYDROLOGIST

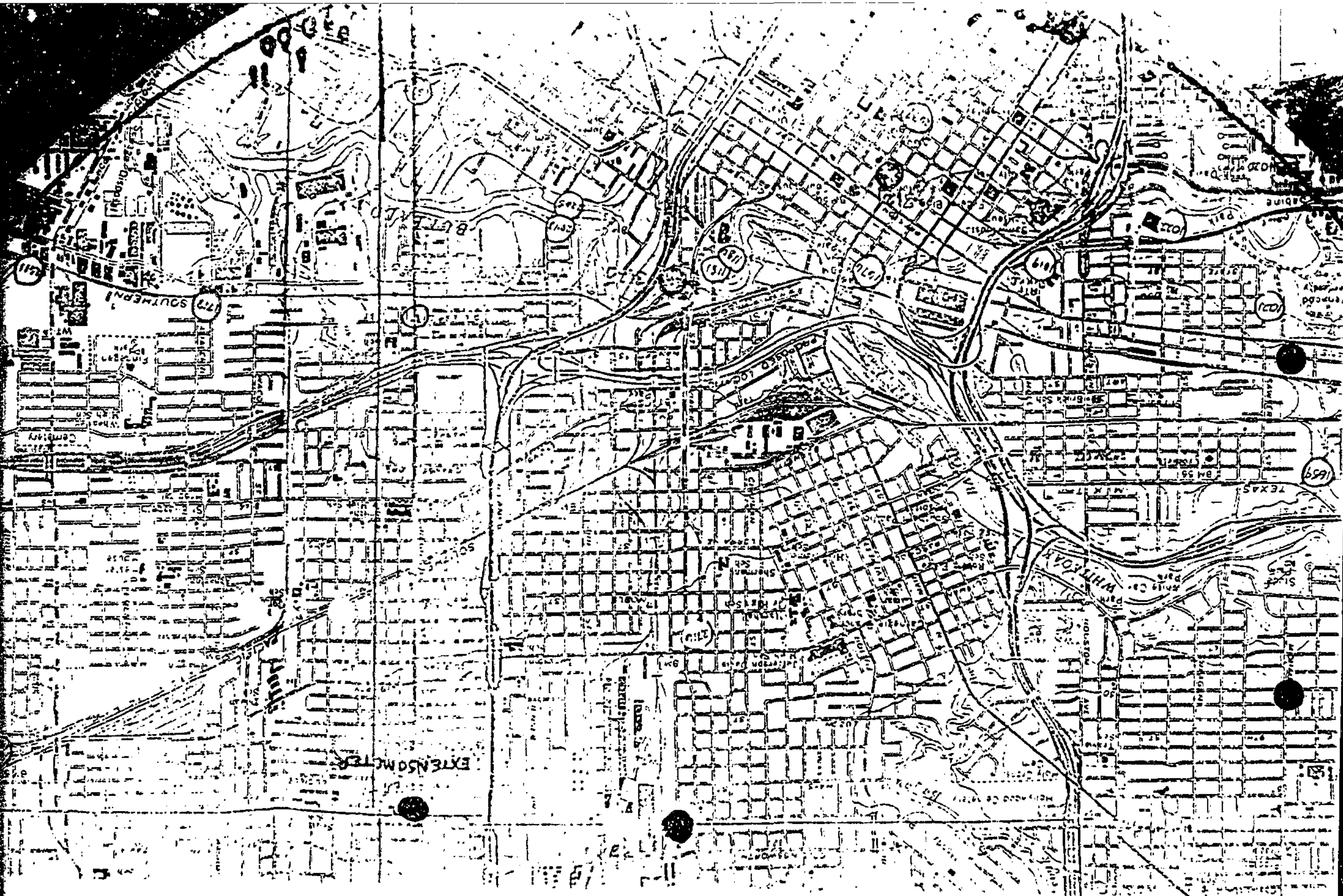
000445

WELL NO.	OWNER'S NAME	[illegible] WELL NO.	LATITUDE	[illegible]	[illegible]	[illegible] DIAM.	[illegible] TO [illegible] SCREEN	TOTAL DEPTH	[illegible]
1576	GENERAL PORTLAND INC.	[illegible] 5	294523	9520 5	50	[illegible]	500	612	[illegible]
2637	TISHMAN MANAGEMENT OF HOUSTON	65-14-7 0	294527	95211[illegible]	50	1[illegible]	0	900	[illegible]
3624	FIRST CITY NATIONAL BANK	65-14-7 0	294536	952142	50	[illegible]	155	550	1981
2265	SWANN ICE SERVICE, INC., C. H.	65-14-7 0	294541	9520[illegible]	25	[illegible]		0	[illegible]
2843	HOUSTON SHELL & CONCRETE	65-14-7 0	294544	952036	19	[illegible]	600	640	[illegible]
1022	HOUSTON, CITY OF	65-13-9 5	294545	952238	43	24	745	2020	195[illegible]
1180	HOUSTON LIGHTING & POWER COMPANY	65-14-7 11	294550	952110	42	18	760	887	19[illegible]
1019	HOUSTON, CITY OF	65-14-7 7	294552	9522 8	25	[illegible]	884	2035	194[illegible]
1181	HOUSTON LIGHTING & POWER COMPANY	65-14-7 4	294553	9521 8	39	24	900	1500	1949
1676	SOUTHLAND CORPORATION, THE	65-14-7 0	294553	952137	45	18	622	900	194[illegible]
1807	BUILDERS SUPPLY CO. OF HOUSTON	65-14-7 0	294557	9521 0	30	4	0	0	19 0
3625	BUILDERS SUPPLY CO. OF HOUSTON	65-14-7 0	294557	952059	30	6		0	1981
1718	COMET RICE MILLS, INC.	65-14-8 0	294558	951923	45	12	425	617	[illegible]
1021	HOUSTON, CITY OF	65-13-9 4	2946 1	952258	46	[illegible]	999	1960	1949
19[illegible]	NATIONAL VINEGAR COMPANY	65-14-7 0	2946 3	9520 8	45	4	486	506	1968
1952	NATIONAL VINEGAR COMPANY	65-14-7 0	2946 3	9520 8	45	4	486	506	1968
1659	COOK PAINT & VARNISH COMPANY	65-13-9 0	294628	9523 7	55	1[illegible]	0	502	1965
2716	[illegible], INC.	65-14-7 0	294656	9521 4	80	[illegible]	0	0	19 0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1200	[illegible]
				[illegible]	[illegible]	1[illegible]	[illegible]	[illegible]	[illegible]

1788	[illegible]MAR HOTEL	65-13-6	294730	[illegible]	[illegible]	[illegible]	0	0	[illegible]
2169	HARDING, GEORGE F.	65-13-9 0	294730	[illegible]	60	[illegible]	[illegible]	[illegible]	[illegible]
1084	HOUSTON, CITY OF	65-14-4 6	294743	[illegible]	50	[illegible]	[illegible]	199[illegible]	[illegible]
2910	CROZIER-NELSON CHEM & CONST.	65-14-4 0	294748	952050	55	0	0	0	19[illegible]0
1086	HOUSTON, CITY OF	65-14-4 4	2948 5	9520 9	50	24	999	1900	194[illegible]

WELL NO.	OWNERS NAME	STATE WELL NO.	LATITUDE	LONGITUDE	ELEV.	CASING DIAM.	DEPTH TO 1ST SCREEN	TOTAL DEPTH	YEAR DRILLED
2334	FREEDMAN BROTHERS PACKING CO.	65-14-4 0	294814	952033	146	6	360	511	1972
1085	HOUSTON, CITY OF	65-14-4 5	294815	9520 9	50	24	735	2080	1949
2270	GOODWILL INDUSTRIES OF HOUSTON	65-14-431	294829	952027	52	10	49	[illegible]9	1955
2770	GULF OIL COMPANY - U.S.	65-13-6 0	294834	952239	60	4	0	240	1975
3214	TRUMIX CONCRETE COMPANY	65-14-422	294845	952057	55	6	0	0	1972
3215	TRUMIX CONCRETE COMPANY	65-14-420	294845	952057	55	6	456	[illegible]78	1971
1087	HOUSTON, CITY OF	65-14-4 3	2949 9	9520 4	55	24	999	1839	1949
2017	GIFFORD-HILL & COMPANY, INC.	65 14-4 0	294911	95[illegible]129	63	6	460	560	1967
23[illegible]	LONE STAR INDUSTRIES, INC.	65-14-4 0	294916	95[illegible]	[illegible]	6	500	548	1974
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1?01	1949


SITE
HOUSTON
000447



000448

Climatic Atlas of Texas

LP-192

TEXAS DEPARTMENT OF WATER RESOURCES

DECEMBER 1983

NOVEMBER

Average Monthly Precipitation

In Inches, 1951-1980

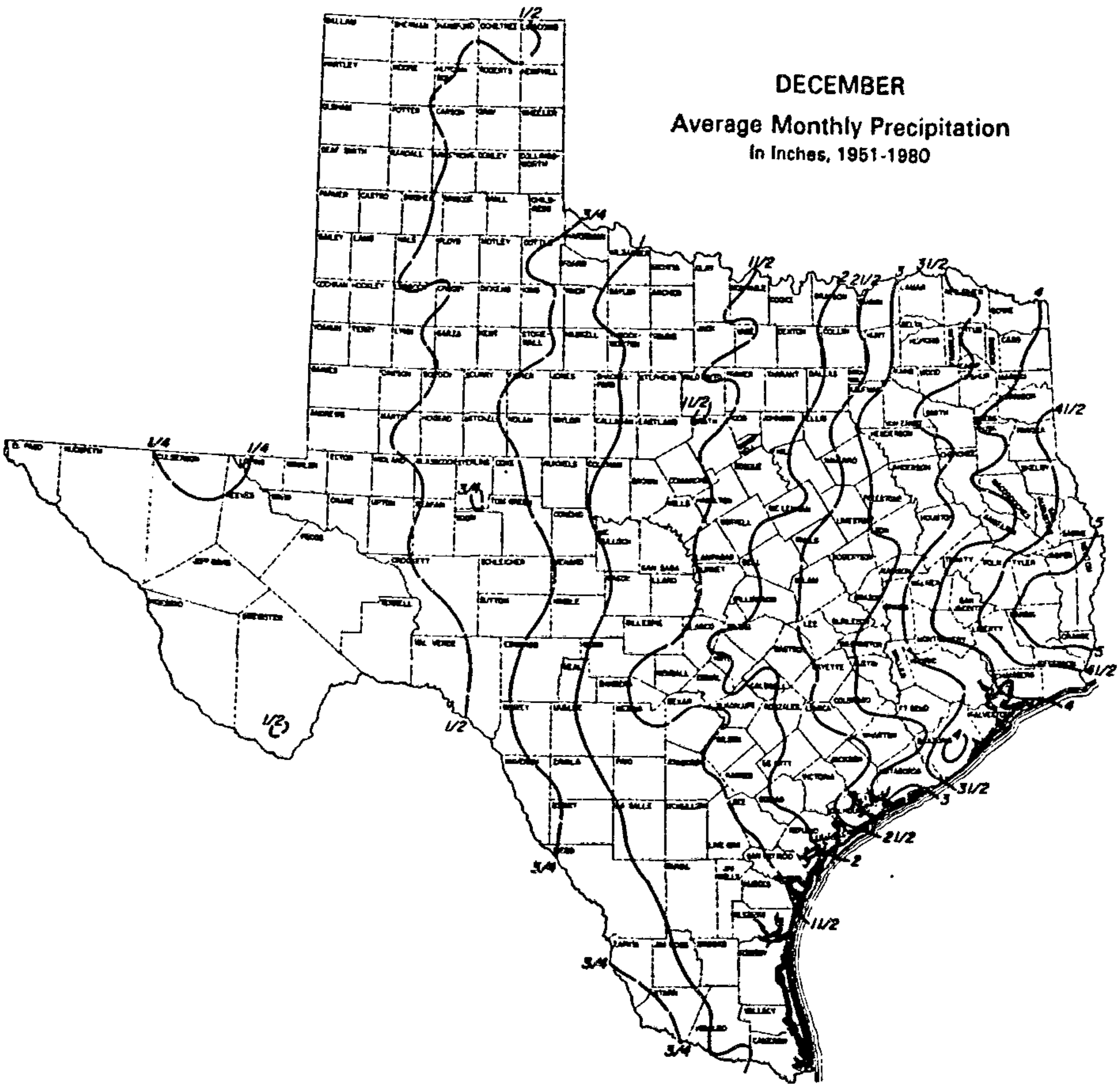
000450

000450

DECEMBER

Average Monthly Precipitation

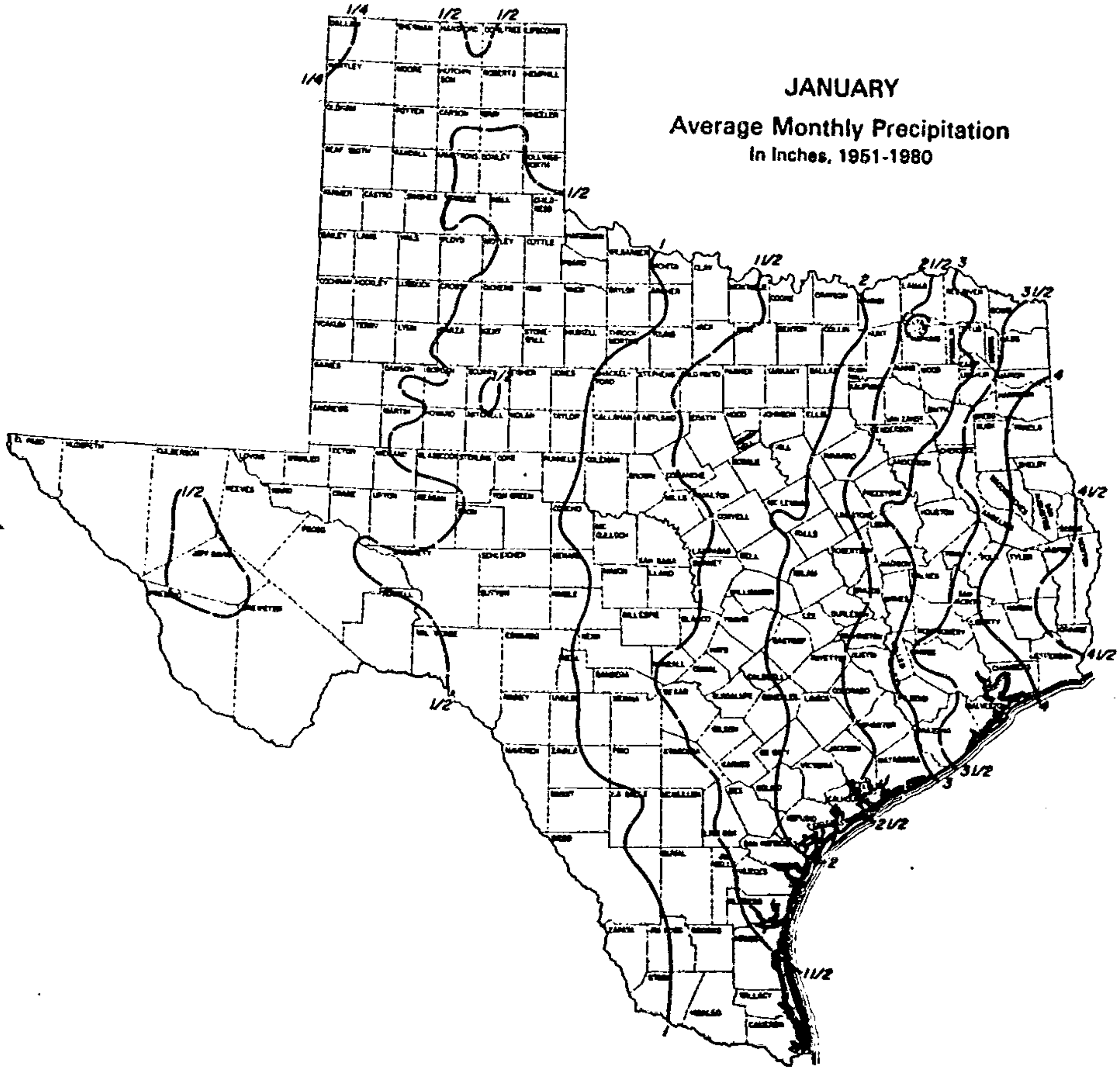
In Inches, 1951-1980



JANUARY

Average Monthly Precipitation

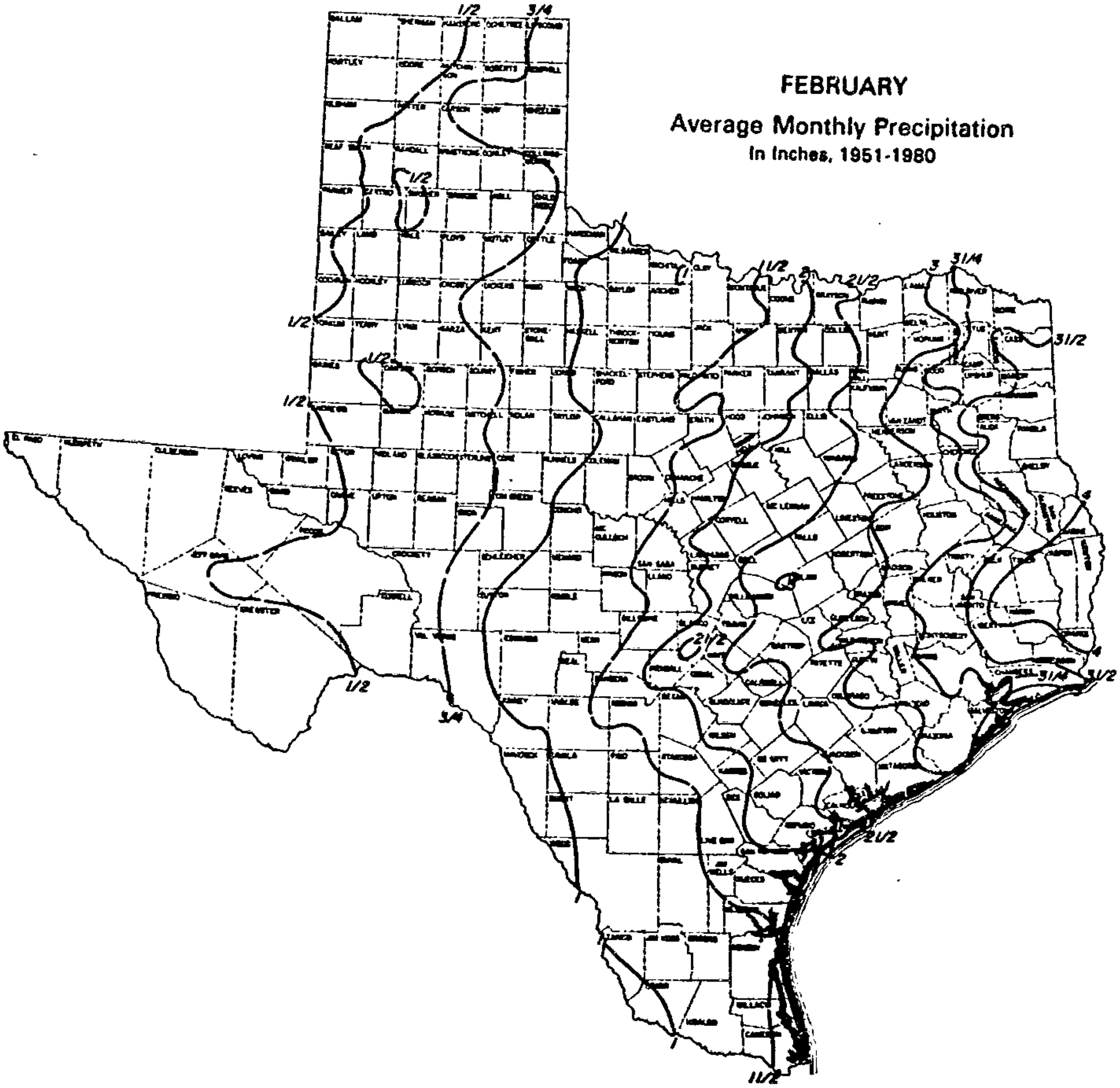
In Inches, 1951-1980



FEBRUARY

Average Monthly Precipitation

In Inches, 1951-1980

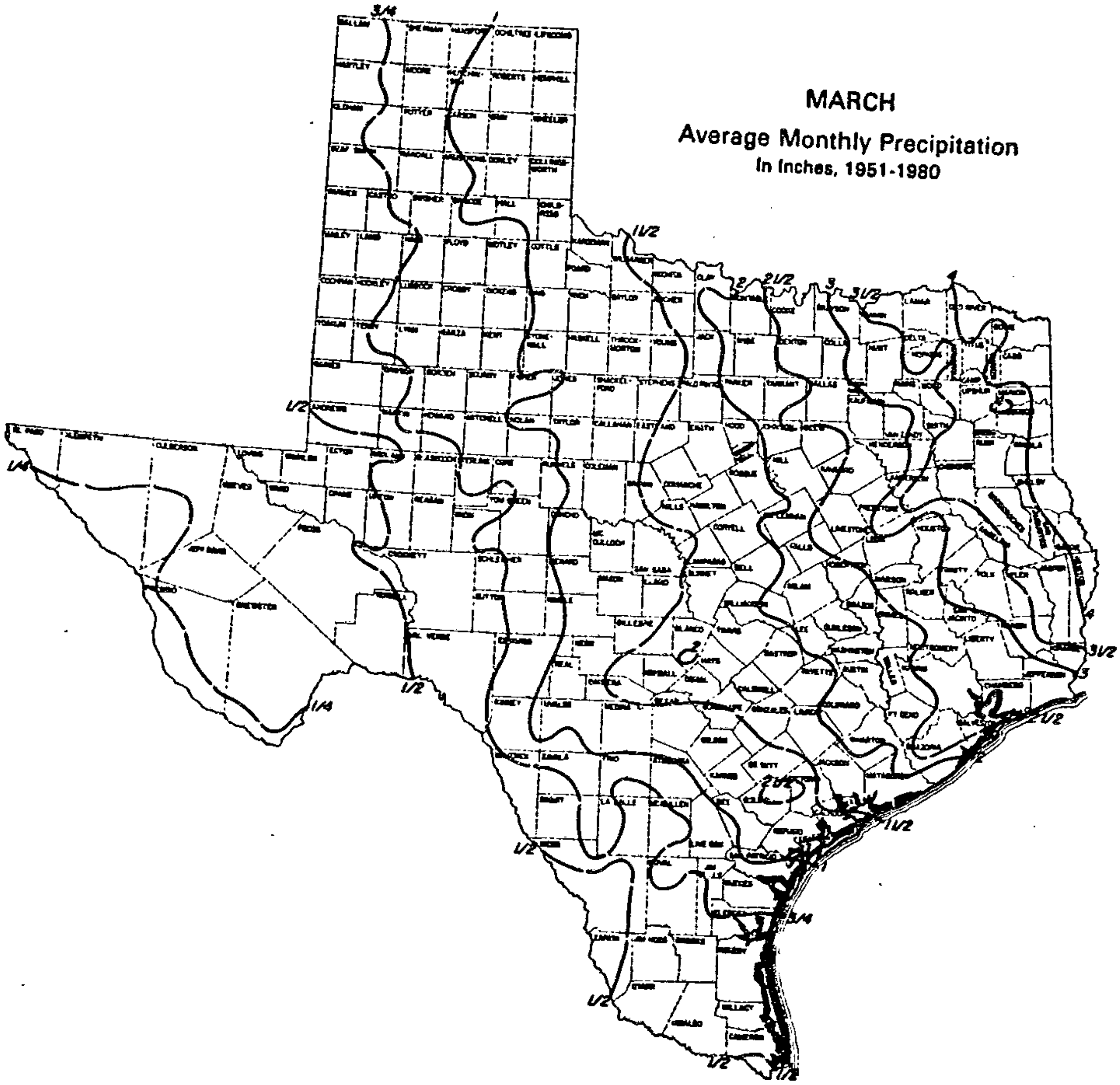


000453

MARCH

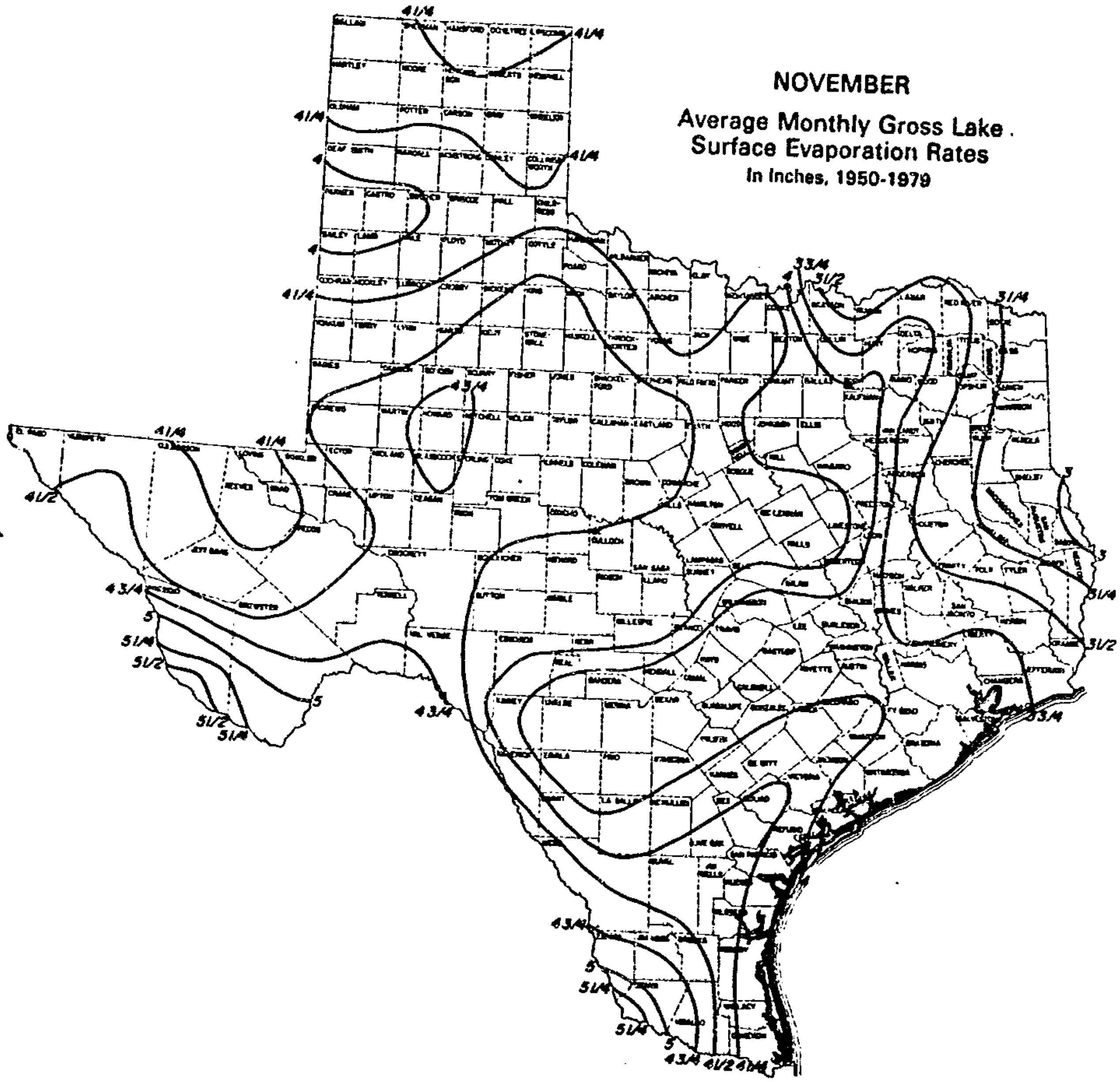
Average Monthly Precipitation

In Inches, 1951-1980



000454

APRIL
Average Monthly Precipitation
In Inches, 1951-1980

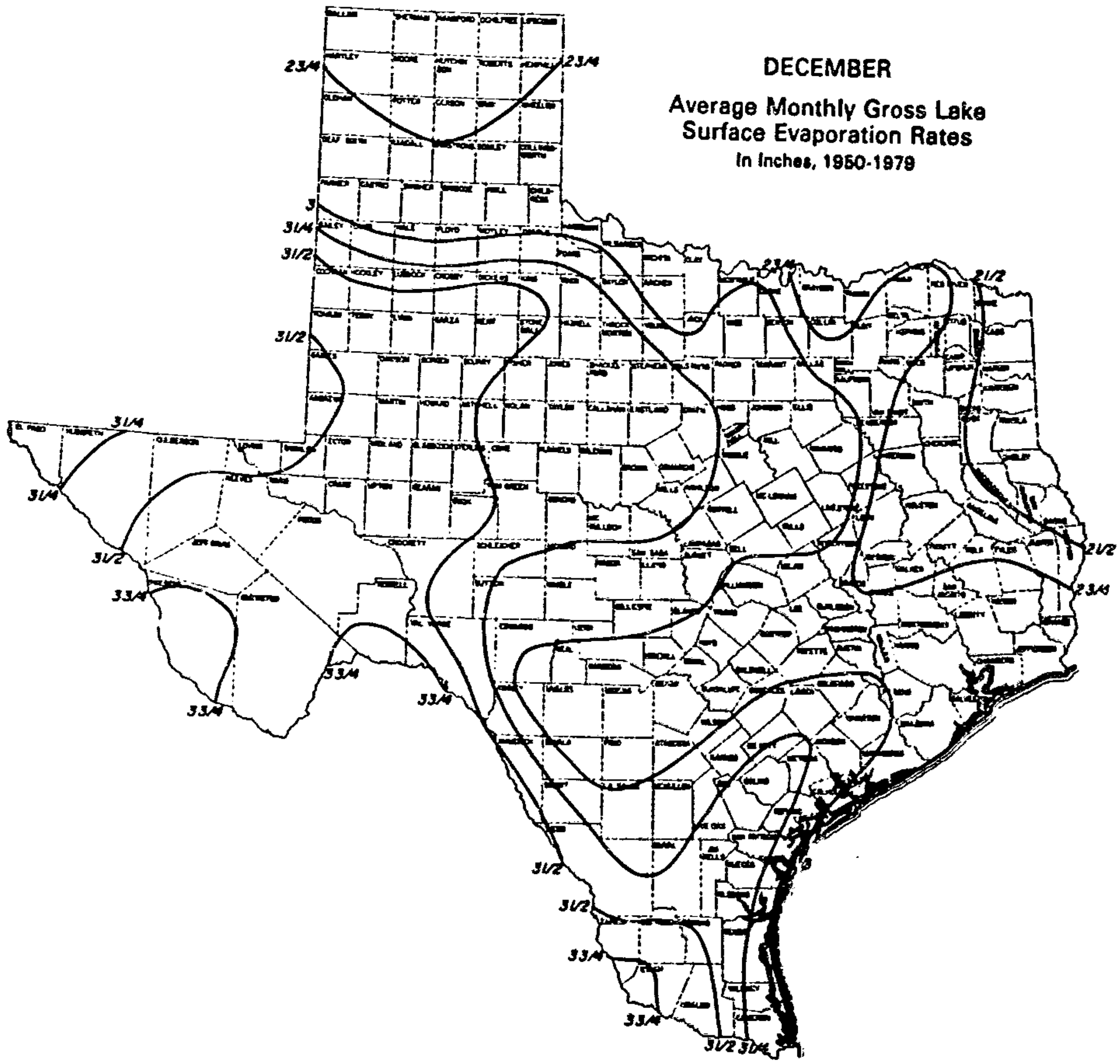


NOVEMBER

Average Monthly Gross Lake Surface Evaporation Rates
In Inches, 1950-1979

000456

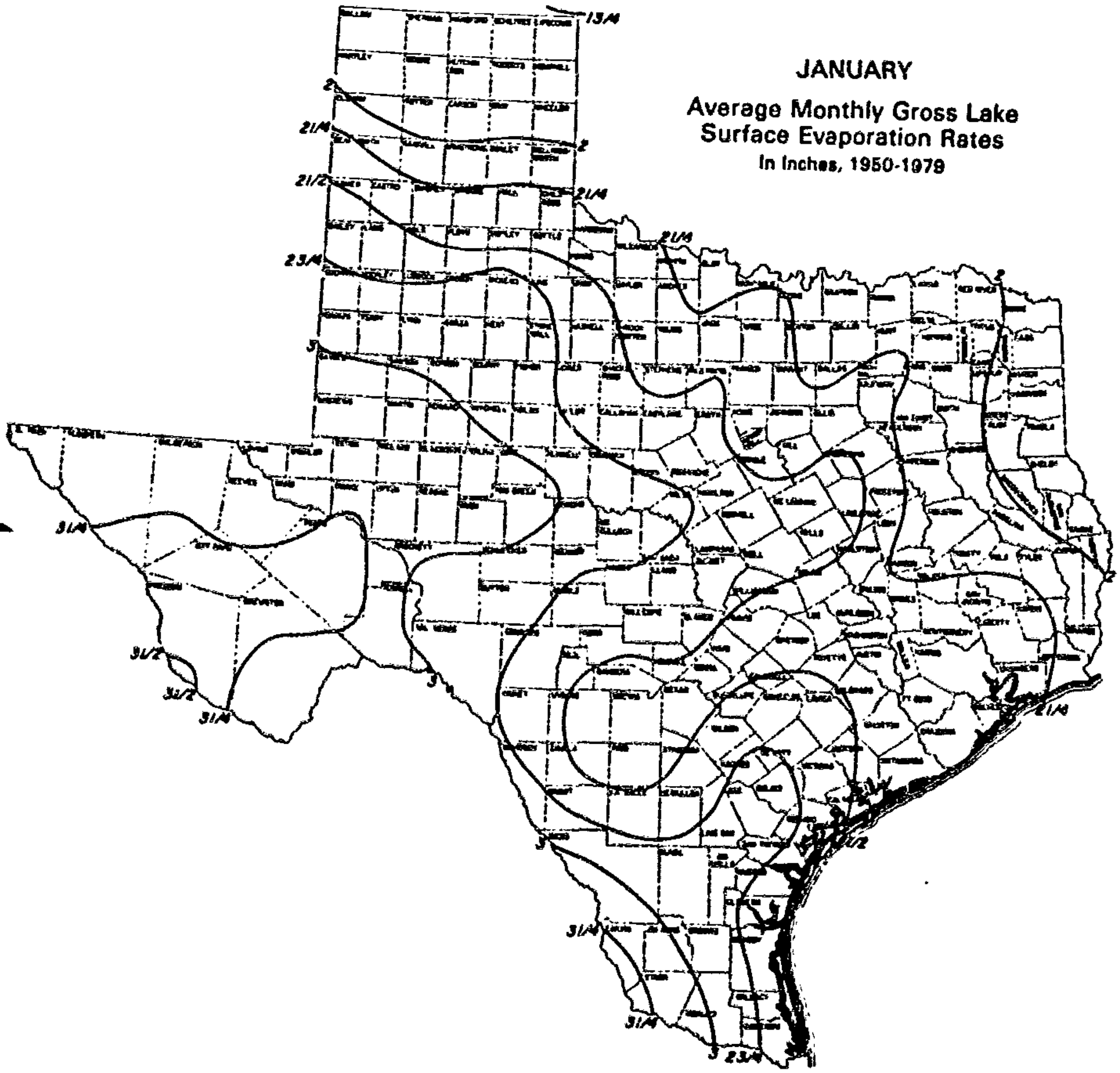
000456



DECEMBER

Average Monthly Gross Lake Surface Evaporation Rates
In Inches, 1950-1979

000457



JANUARY

Average Monthly Gross Lake Surface Evaporation Rates

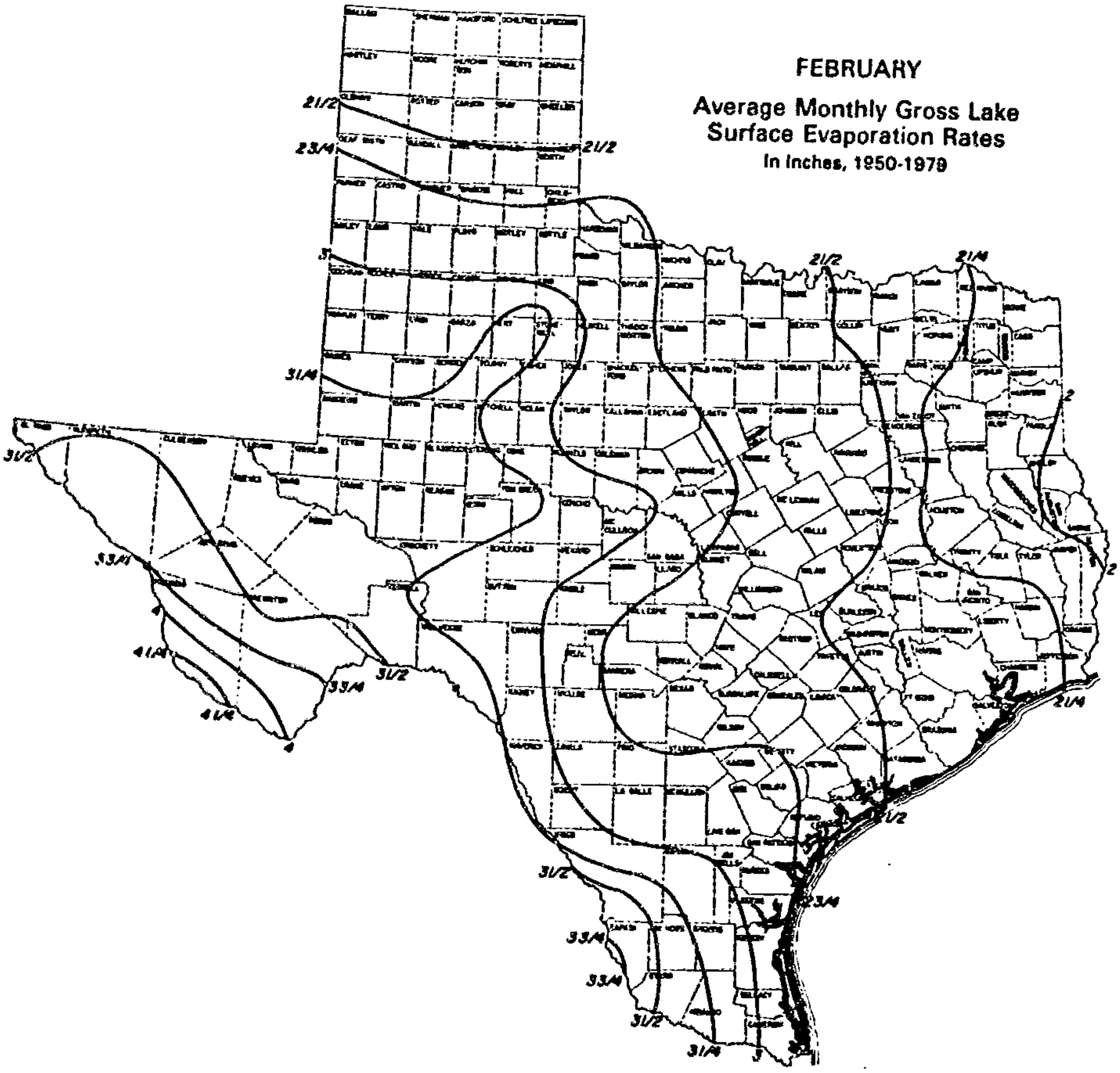
In Inches, 1950-1979

000458

FEBRUARY

Average Monthly Gross Lake Surface Evaporation Rates

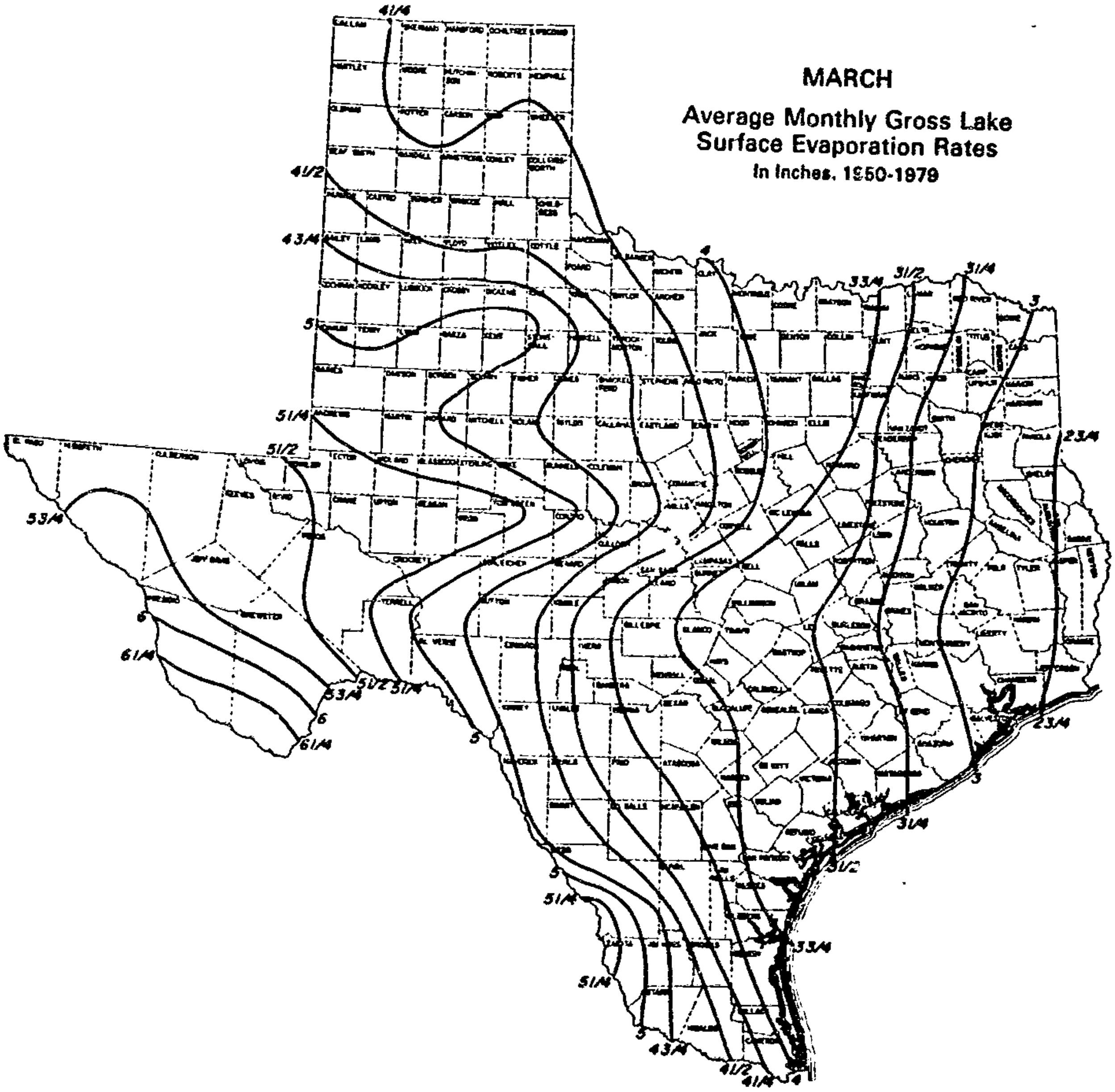
In Inches, 1950-1979



MARCH

Average Monthly Gross Lake Surface Evaporation Rates

In Inches, 1950-1979



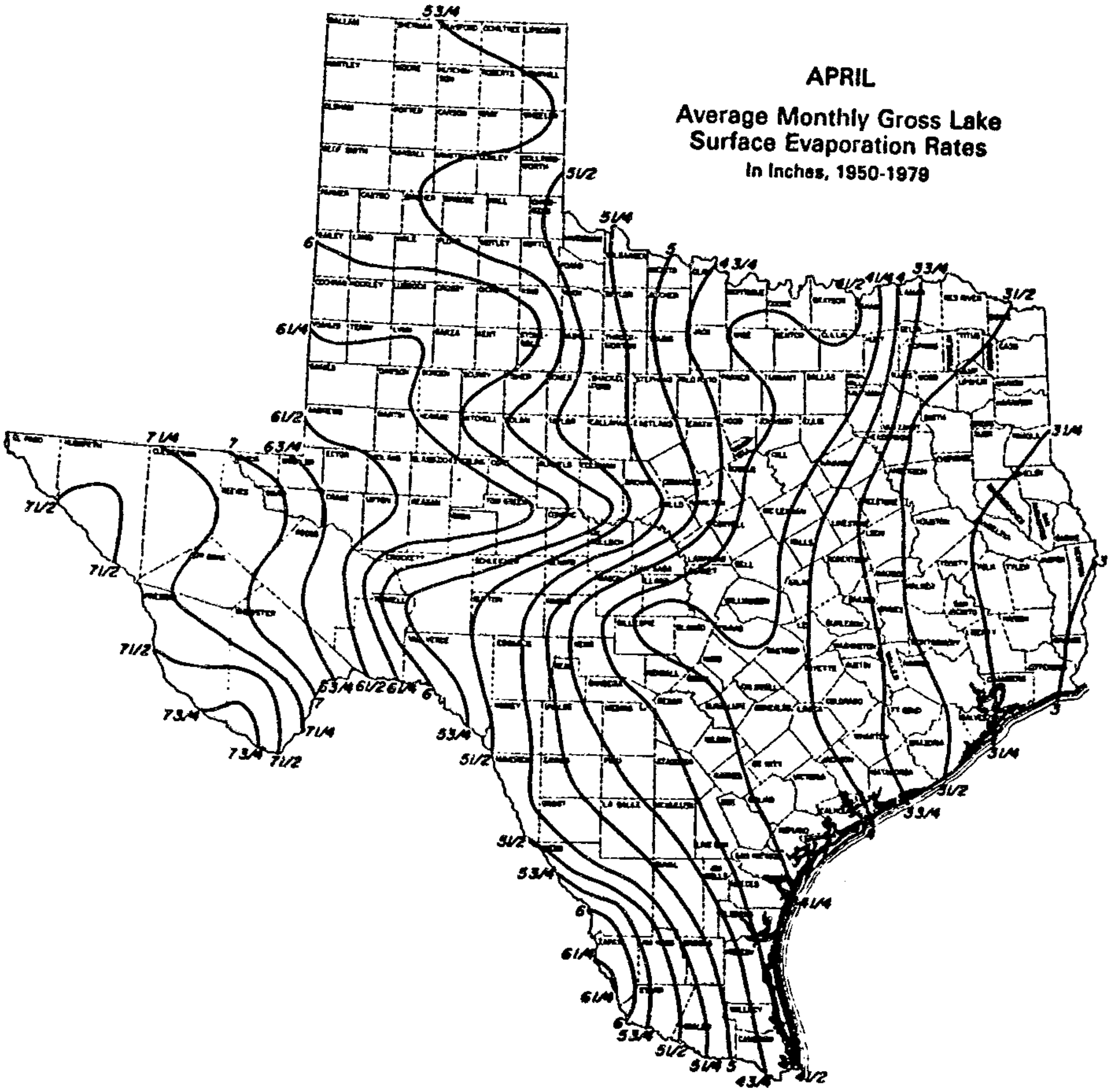
000460

000460

APRIL

Average Monthly Gross Lake Surface Evaporation Rates

In Inches, 1950-1979



000461

000461